THE ENGINEER.

The London and North-Western Railway and Crewe Works.

THE LONDON AND NORTH-WESTERN RAILWAY AND CREWE WORKS.

INTRODUCTION.

THE London and North-Western Railway, as it is to-day, is probably historically the most interesting system of intercommunication ever constructed. Although many other railways came into existence about the same time, they all followed the example set them by the Stephensons. We do not ignore the claim of the Stockton and Darlington Railway to be the first line that ever carried passengers; but the work was done on so small a scale, and led to so little, that the claim that the railway system of the world began with the construction of the road between Liverpool and Manchester, and the victory of the Rocket at Rainhill, cannot be disputed. And the intelligent management of the affairs of the company, and the skill, talent, and energy of its officers, have built up a railway system the efficiency and excellence of which cannot be exceeded. The London and North-Western Railway system began with the thirty miles line linking Liverpool and Manchester. The company expected to earn £10,000 a year from passenger traffic. The first year the receipts were £101,829. Goods were expected to give £50,000. They gave over £80,000. No wonder there was a boom in railways. In 1846, the London and Birmingham, the Grand Junction, which under another Act had already been incorporated with the Liverpool and Manchester, and the Birmingham and Manchester Railway, were amalgamated under the title of the London and North-Western Railway. Between 1846 and 1849 the South Staffordshire, the Chester and Holyhead, the Lancaster and Carlisle, and some forty smaller companies were absorbed. Some of these were only leased. In 1877 a consolidation Act was passed, welding these undertakings into one homogeneous whole. We propose in the following pages to lay before our readers—and particularly our younger readers—some of the more salient features of the history of the line. We shall first refer to the construction of the London and Birmingham section, with a reference to the great bridge crossing the Menai Straits. We shall then deal with the development of the locomotives working the system; then some notes on the method of conducting traffic in the early days; and conclude with a description of the Crewe Works as they are to-day.

EARLY HISTORY.

The Liverpool and Manchester Railway was linked up with Birmingham by the Grand Junction Railway. A line from London to Birmingham was proposed in 1825, but nothing was done. There was no satisfactory scheme prepared for working such a road. The Liverpool and Manchester line was opened in September, 1830. Then Birmingham moved. George Stephenson and his sons were appointed engineers to the proposed line. Plans were prepared, and the Bill for it was passed in the Commons in the session of 1832. It was thrown out by the Lords, revived in the following year, and coupled with a Bill for the construction of the above-named Grand Junction Railway, which had been surveyed by Joseph Locke and the Stephensons. Both Bills became law in the same year. We do not intend to do more than glance at the early history of the London and Birmingham Railway. As shown on the original map, dated 1839, the length of the line was 112 miles. The estimate laid before Parliament was £2,500,000, everything included; as, for example, £61,000 for rolling stock, engines, and tenders. It need scarcely be said that the estimate was greatly too small. Thus the estimates for rails, chairs, &c., was £213 000. Actually there were used 35,000 tons of rails, costing £460,000, or, say, £13 6s. per ton. The sleepers were stone blocks weighing 152,000 tons, and costing £180,000. Of this one-third was the price of the stone, one-third freight to the Thames, and one-third carriage to the railway. All this was absolute waste, as the blocks had to be taken up after a few months' trial and replaced by wooden sleepers.

The line was opened throughout in September, 1838, but for a few months previously travellers were conveyed to Denbigh Hall, and from Rugby to Birmingham by rail. The intermediate distance was worked by horse coaches. It seems that much inconvenience was now and then occasioned by lack of road vehicles. As far as the railway was concerned, any number of passengers could be carried; but on the middle ground there was a limit. For several days before the coronation of Queen Victoria every seat from Birmingham to London was booked; and hundreds of persons who went to Birmingham in the expectation of getting to London by rail were disappointed. As much as £20 was offered for a seat. Denbigh Hall is not far from Wolverton, and during the period that it was a terminus it acquired a factitious importance, a fact which was subsequently utilised by promoters to prove their argument that a railway must do good even in out-of-the-way country places.

The traffic of the line was worked by locomotives from Camden Town to Birmingham, but the rather heavy incline between Euston and Chalk Farm—about 1 in 70—was worked by ropes, two winding engines being established at Chalk Farm. These engines were placed underground. It does not appear that any drawings or engravings of them exist. These engines were each 60 nominal horse-power, with main rope pulleys 20ft. in diameter. They would perhaps indicate three times their nominal power. They were constructed by Maudslay and Field, and were probably side lever marine engines, similar to those used for working the Blackwall rope railway, which were afterwards used for many years to drive the machinery in the City Flour Mills, the building of which may still be seen near the lower end of Upper Thames-street. Two very handsome chimneys stood at Camden Town, one at each side of the cutting. These chimneys were not removed until a comparatively recent period, long after the use of the rope had been given up. As there were no electric signals, a very ingenious arrangement was employed to let the enginemen at Camden Town know when to begin winding. In the engine-house was placed a large whistle—in point of fact an organ pipe. An iron tube was laid along the line from this pipe to Euston. There the tube turned upwards, passing watertight through the bottom of an iron cylinder in which was water. An inverted bell with its edge in the water hung over it. It was only necessary to send the bell down sharply by a lever to drive the air which it contained into the tube, and so blow the whistle in the engine-house at the other end. The transmission of the signal occupied about four seconds. The coupling of the train to the rope was very primitive. "Great precaution," we are told, "is required in attaching the carriages to the rope; and this is generally done by one man, who is trained for that purpose. The way in which he effects the fastening is by means of a small rope or messenger having a slip-knot at one end which he passes over the rope, and holds the other in his hand as he stands on the foremost carriage, in order to release the train when it reached Camden Town, or in case of accident, by a signal given to the engineer the engines are stopped in an instant. The train is generally drawn up this length of railway in three or four minutes."*

A glance at the history of the London and Birmingham Railway suffices to show that many mistakes were made. Contractors were ruined, and estimates largely exceeded. But it must not be forgotten that these things were quite inseparable from the conditions under which the work of construction was carried on; and we should rather praise the engineers and contractors for their courage, their indomitable energy and resource, than censure them for an ignorance which it was impossible to avoid. Apart from the trouble experienced in crossing Chat-moss, the Liverpool and Manchester line presented few engineering obstacles. The route from Birmingham

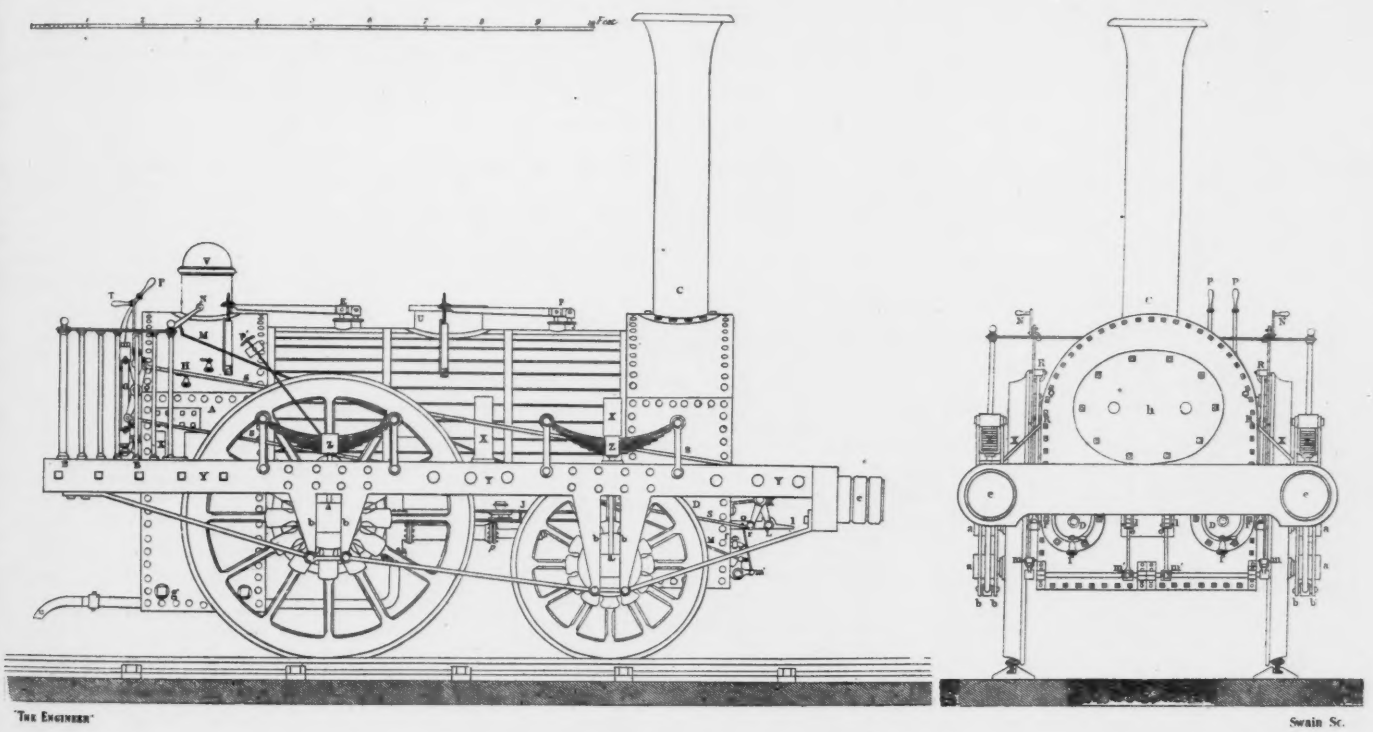


Fig. 1—AN INSIDE CYLINDER ENGINE OF 1836

* "The London and Birmingham Railway," by Thomas Roscoe. The date of the book is not stated—probably about 1838 or 1839.

to London was very different. The tunnels represented serious difficulties; experience in tunnelling was very small; there were very few tunnels of any importance in existence. No one would have dreamed in those days of such works as the St. Gothard or the Simplon; yet with a light heart the construction of tunnels which even in the present day would be regarded as serious work, was undertaken. As an example, we have selected the Kilsby

stance occurred; when trial borings were made from the surface little water was found, but when the second shaft was being sunk a basin or pocket of sand and gravel, full of water, was struck. This pocket had been missed by the trial borings. It was impossible to proceed with the shaft. Stephenson concluded, however, that as the basin lay high, it was possible that it was not water fed by powerful springs, and that it could be pumped dry.

ventilating shafts is 60ft. and the other 130ft. deep. Each is 60ft. in diameter. It was ultimately found that the quicksand—it was little better—extended for over 400 yards along the tunnel, the bottom of it being in places not more than 6ft. above the crown of the brickwork. The ventilating shafts involved only work comparatively familiar, being, in fact, mine shafts, only very much larger in diameter. They were put down without curbs by excavating a

LIVERPOOL AND MANCHESTER RAILWAY.

Abstract of WORK performed, and COKE consumed by LOCOMOTIVE ENGINES, during the Week, ending Saturday,

July 4th 1840

NAME OF ENGINE.	Trips of Thirty Miles.	Coke consumed in Trips. c.	q.	lbs.	Coke consumed per Trip. c.	q.	lbs.	Average Load Coaches.	Name of Engineman.	Name of Fireman.
COACHING ENGINES.										
Comet	12	62	2	0	5	0	23	7½	Hindley	Clarke
Cyclops	16	86	1	0	5	1	16	8	Wood	Knight
Swiftsure	12	68	3	0	5	2	26	9	Cunliffe	Jameson
Etna	12	73	3	0	6	0	16	7	Jakeman	Hodson
Plato	14	90	0	0	6	1	20	9	Cunliffe	Jameson
Mile	14	93	3	0	6	2	22	7	Jakeman	Hodson
Spadewell	26	176	1	0	6	3	3	8½	Thompson	Wilson
Vesta	14	95	0	0	6	3	14	8½	Grenall	Sanderson
Arrow	10	71	1	0	7	0	14	7	Wood	Knight
Rapid	2	17	2	0	8	3	0	7½	Death	Murry
Total	132	835	0	0	6	1	5	.	236 lbs per Mile	

NAME OF ENGINE.	Trips of Thirty Miles.	Coke consumed in Trips. c.	q.	lbs.	Coke consumed per Trip. c.	q.	lbs.	Average Load Waggons.	Name of Engineman.	Name of Fireman.
LUGGAGE ENGINES.										
Titan	12	91	1	0	7	2	12	20	Jumeu	J. Slater
Comet	12	98	3	0	8	0	25	20	Hindley	Clarke
Mastodon	12	98	3	0	8	0	25	20	Derbyshire	Pursell
Panther	2	20	1	0	10	0	14	15	Death	Murry
Eclipse	6	67	2	0	11	1	0	23	Taylor / Stirrock	Rigby / Slate
Thunderer	4	47	2	0	11	3	14	22	Robinson	Haughton
Buffalo	2	31	1	0	15	2	14	32	Stirrock	Green
Hercules	8	128	3	0	16	0	18	31	Guest	Davies
Total	58	504	0	0	11	0	5	.	37 6 lbs per Mile	

"The Engineer" Edw. Woods Swain Sc.

Fig 2—FAC-SIMILE OF PAY-SHEET, 1840

Tunnel. Two supplements to this issue illustrate the head gear at the great shaft and the pumping plant.

THE KILSBY TUNNEL.

The tunnel lies under the Kilsby ridge, not far on the London side of Rugby. It is 2423 yards long. Most of the

Steam pumps were provided, and suitable wells sunk close to the line of the proposed tunnel. The scheme was ultimately successful. After nine months of continuous pumping from eighteen drainage shafts it became possible to put down the main shafts and to proceed with the tunnel. Our coloured supplements, reproductions of sketches made on the spot by J. C. Bourne, show

portion of the circumference from 6ft. to 10ft. long and about 10ft. deep, the core of earth or shale being left standing until a complete ring 10ft. deep had been completed. Then the same operation was repeated. In November, 1836, there was a violent irruption of water into the tunnel, and work was carried on from a raft, on which men and materials were floated into the tunnel at

LIVERPOOL AND MANCHESTER RAILWAY.

Abstract of WORK performed, and COKE consumed by LOCOMOTIVE ENGINES, during the Week, ending ~~Saturday~~ Friday

August 7 1840

NAME OF ENGINE.	Trips of Thirty Miles.	Coke consumed in Trips. c.	q.	lbs.	Coke consumed per Trip. c.	q.	lbs.	Average Load Coaches.	Name of Engineman.	Name of Fireman.
COACHING ENGINES.										
Cyclops	6	36	0	0	6	0	0	8	Wood	Knight
Swiftsure	10	68	3	0	6	3	14	9	Cunliffe	Todd
Phenix	16	111	0	0	6	3	14	8½	Grenall	Davies
Spadewell	14	98	3	0	7	0	6	8	Slater	Hindley
Plato	14	98	3	0	7	0	21	9	Cunliffe	Todd
Vesta	10	72	2	0	7	1	0	8½	Grenall	Davies
Comet	20	146	1	0	7	1	7	9	Hindley	Clarke
Mile	12	90	0	0	7	2	0	9½	Jakeman	Hodson
Dart	16	120	0	0	7	2	0	10	Hardy	Dixon
Arrow	8	60	2	0	7	2	7	8½	Wood	Knight
Etna	14	107	2	0	7	2	20	9	Jakeman	Hodson
Panther	2	18	3	0	9	1	14	8½	Purdy	Murry
	132	957	3	0	7	1	1	.	271 lbs per Mile	

NAME OF ENGINE	Trips of Thirty Miles.	Coke consumed in Trips. c.	q.	lbs.	Coke consumed per Trip. c.	q.	lbs.	Average Load Waggons.	Name of Engineman.	Name of Fireman.
LUGGAGE ENGINES.										
Titan	8	48	3	0	6	0	10	16½	Jumeu	J. Slater
Mastodon	16	113	3	0	7	0	12	16	Derbyshire	Pursell
Cyclops	6	45	1	0	7	2	5	18	Wood	Knight
Arrow	6	59	2	0	9	3	19	19	do	do
Eclipse	12	121	1	0	10	0	12	26	Taylor	Rigby
Thunderer	12	157	1	0	12	2	12	26	Robinson	Haughton
					Premium					
					Enginemen			Firemen		
Coaching		No Premium						No Premium		
Luggage		½ Penee						½ Pence		
Bank		No Premium						No Premium		
Jobbing		do						do		
Total		½						½		
	60	539	3	0	9	0	0	.	33 6 lbs per Mile	

"The Engineer" Edw. Woods Swain Sc.

Fig. 3—FAC-SIMILE OF PAY-SHEET, 1840

lining is 27in. thick, of brickwork laid in cement. It was begun in June, 1835, but the contractors gave the job up in the following March, and the company had to complete the tunnel, as it was found impossible to estimate for it, because of water. The strata is generally lias shale, which is very untrustworthy. A curious circum-

the head works, and pumping and winding plant, with the bell-cranks and transmission rods. The pumping averaged 1800 gallons per minute. There were twelve steam engines and 1300 men at work day and night. The winding of soil excavated was largely done by horse whims, as shown in one supplement. One of the two

great personal risk. The whole work was completed in October, 1838. The original contract was £99,000; it actually cost over £300,000, or about £130 per yard. Thirty millions of bricks were used. The weight of the tunnel has been calculated at 118,000 tons. If the bricks were laid end to end they would reach 4260 miles. The

quantity of soil removed was 177,000 cubic yards. The resident engineer was Mr. Charles Lean, and to him was due the carrying through of the work to a successful termination.

It is worth while to say here in this twentieth century, when tubes and tunnels abound, that the prejudice which existed against the latter in the early days of railroads was so strong, and promised to be so mischievous, that special exertions had to be made to combat it. Thus a visit of experts was arranged by the directors of the London and Birmingham Railway to the Primrose Hill tunnel. This committee consisted of Drs. Paris and Watson, Surgeons Lawrence and Lucas, and Mr. Phillips, a lecturer on chemistry, the object being to ascertain the probable effect of such tunnels on the health of passengers. They reported that they found the atmosphere of the tunnel to be dry, free from smell, and of an agreeable temperature. The lamps of the carriages were lighted; and on the trip inwards and back again to the mouth of the tunnel, "the sensation was precisely that of travelling in a coach at night between the walls of a narrow street." The noise did not prevent easy conversation, nor appear to be much greater in the tunnel than in the open air. Judging from the experiment, the committee came to the conclusion, "knowing the ease and certainty with which thorough ventilation might be effected, that no danger occurred in passing through well constructed tunnels; and that the apprehension that had been expressed that such tunnels were likely to prove detrimental to health and unpleasant to travellers, were perfectly futile and groundless," and to that opinion they all signed their names. It would appear that in its old age the Primrose Hill tunnel scarcely retains the immaculate reputation then conferred on it. It may be added here that of the whole line thirteen miles in all are level, fifty-two on inclines of 1ft. to 14ft. per mile, and forty-seven miles on inclines of 14ft. to 16ft. to the mile. From London to Birmingham fifty-four miles ascend and forty-four descend. The greatest difference of level between any two parts of the line is 308ft., and the gradients change forty-four times. At the time the line was opened it occupied about 2000 acres, but the acreage has been largely augmented. The Trent Valley road came into existence long afterwards.

THE BRITANNIA BRIDGE.

Two other supplements are based on original drawings made while the construction of the great Britannia Bridge, linking up the island of Anglesey with Wales, was in course of construction. The bridge spans the Menai Straits. No doubt the greater number of our readers know that it consists of rectangular iron tubes with cellular tops and bottoms, through which the trains pass. The tubes were designed by Fairbairn, but the bridge as a whole by Robert Stephenson. It was begun in 1845, and the first train passed through it in 1850.

The bridge has so often been described that little need be said about it here. The tubes were constructed on the banks of the Straits, placed on pontoons, and floated down to the bridge piers at high water. By a system of guy ropes and capstans they were successfully brought into place, with their ends in grooves in the masonry. As the tide fell the pontoons were removed and the girders rested on seats prepared for them. They were then taken in hand by two huge hydraulic presses overhead, which lifted them by flat link and pin chains, 6ft. at a time, to their place above, the masonry being carried up under them in the grooves. At the termination of a 6ft. lift a set of links was taken out of the chains, and the press plunger suffered to descend. Then a fresh hold was taken of the tube with the shortened chain, the rams were pumped up again, and so on till the whole lift was complete. The lifting plant was very elaborate, well designed, and expensive. It was constructed in 1849 by the Bank Quay Foundry Company, Warrington. The work was all carried out under the direction of Mr. Edwin Clark. The chains were made by Messrs. Howard and Ravenhill, and the clamps and valves by Messrs. Easton and Amos. The greatest weight lifted was 1144 tons, the pressure being 3.819 tons per square inch. The press cylinders each held 81.5 gallons. The pressure is equivalent to a head of 5.41 miles. One of the coloured supplements shows the tubes under construction on the banks of the Straits.

THE DEVELOPMENT OF THE LOCOMOTIVE.

A large volume would hardly suffice to contain a complete history of the wonderful machine which has modified the whole course of civilisation, and provided new systems and methods of living for mankind. But a detailed history is not necessary; it would be quite outside our present purpose. Our object is to show that in spite of all that has been done not only in other countries, but even on our own or other railway systems, the fact remains that the locomotive first assumed its type and characteristics on the Liverpool and Manchester Railway; and from 1829 onwards to the present day the men responsible for the movement of vehicles on the London and North-Western Railway have kept step with other engineers in all parts of the world, so that no one who understands the subject can say without hesitation that there are better locomotives in use on other lines—that is to say, better adapted to discharge the duties which they are daily called upon to perform.

Let us consider for a moment what the modern locomotive is. It is a vehicle; it is a steam generator; it is a steam engine. Now, the first locomotives which travelled on rails were very imperfect vehicles. It may be safely said that the original "Puffing Billy" of the Stockton and Darlington Railway could not have been run, even over modern permanent way, at any but the most moderate speeds. Its boiler was a very poor affair. The engine, bad as it was, was probably better than any other part of the machine. The difference between the Rocket and the Agenoria, or the Puffing Billy, merely regarded as vehicles, was very great; but it was not, after all, greater than that between the Rocket and the Meteor, or Comet, or Arrow. The real difference between the Rocket and the engines which first worked the Liverpool and Manchester Railway was incredibly great. To whom the difference was due is lost in the mists of time. It is very improbable that the Planet type originated with George Stephenson; possibly his son had much to do with it. Most likely of all, a man in the drawing-office planned it out, and subsequent additions and improvements were introduced; something broke and was replaced by that which was not only stronger, but better adapted to its purpose. It would be waste of words to consider with whom the boiler originated, or who first put lap on slide valves, or invented the link motion. The fact of interest is that, so to speak suddenly, there came into existence a vehicle so well adapted to run at high speeds, that in all the years which have elapsed since 1829 and 1830 little change has been found desirable or even possible. The magnificent locomotives of the present day are in all essential characteristics the same vehicles as their progenitors.

We shall do well to keep in mind the fact on which we have insisted. We have heard it said that Braithwaite and Ericsson's engine would have beaten the Rocket, if the blower or the feed pump had not broken down, and that it would have been the type of the future locomotive. We have only to compare it with the Planet type to see that this could never be. The vertical cylinder and boiler, the whole of the arrangements in fact, rendered it impossible that a successful high speed vehicle could be produced on its lines. It may be said truthfully that Stephenson hit, either by accident or intention, on the only design that could have produced a locomotive capable of running at speeds of over 60 miles an hour with entire safety. We may now leave the Rocket on one side, and proceed to consider the first real railway locomotives ever constructed.

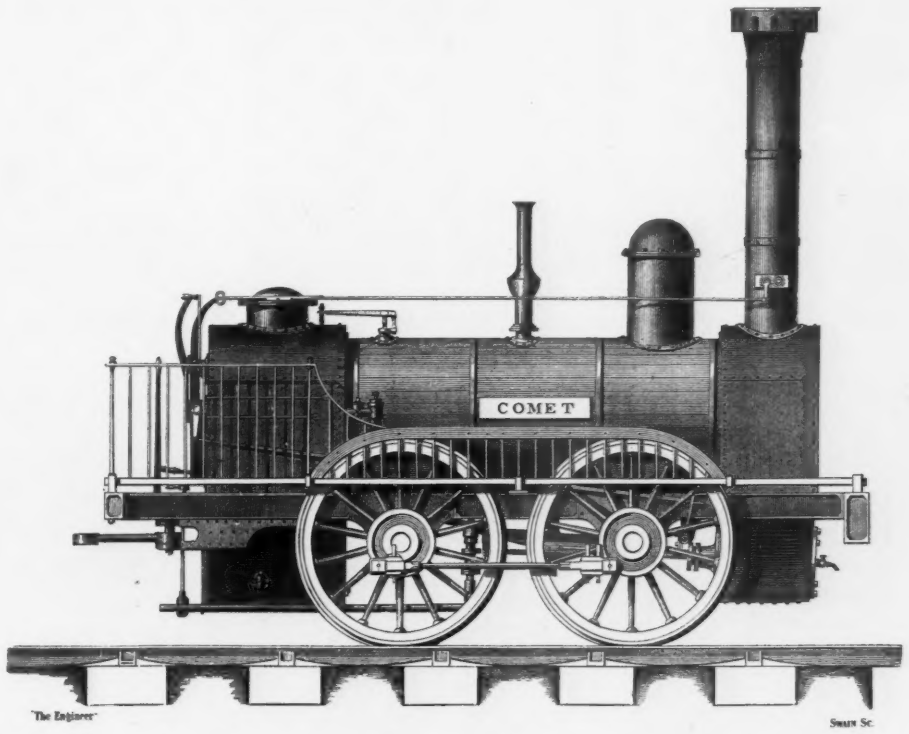


Fig. 4.—THE COMET

EARLY LOCOMOTIVES.

Unfortunately minute details no longer exist in the way of either drawings or descriptions of the rolling stock first used on the Liverpool and Manchester Railway. But we know that between 1832, the date of Nicholas Wood's treatise on railways, and 1836, that of Count Pambour's classical volume, certain improvements in detail had taken place. We find that in the last named year the locomotives of the Manchester and Liverpool Railway were divided into five classes, and were thirty in number. There were originally thirty-two. What became at the time of those missing we cannot say. We believe that the Rocket was one of them. The classification is given in the following table:—

Class.	Diameter of cylinder. in.	Stroke of piston. in.	Diameter of wheels. ft. in.	Weight. tons.	Boiler pressure. lb.
1	14	16	4 6	12	50
2	12	16	5 0	12	50
3	11	16	5 0	8 to 9	50
4	11	18	5 0	8 to 9	50

Pambour writes:—"In the fifth class come the first engines used by the company at the opening of the railway; these cylinders are 10in. in diameter and under, the stroke of the piston, the wheels, and the weight of the engine vary accordingly. But at present they have nearly ceased to be used on the railway; they scarcely ever undergo any repairs, and none of them will figure in any of our experiments. We need, therefore, not enter into any particulars concerning them."

It appears that there were eight engines in this fifth class. Of the others there were:—

Two of 14in. diameter of cylinder.
Four of 12in. diameter of cylinder.
Sixteen of 11in., with a 16in. stroke.
Two of 11in., with an 18in. stroke.

Accurate engravings of these engines are exceedingly scarce; perhaps because they were not built from detail drawings in the modern way. One or two original drawings may be seen at South Kensington. They are little more than sketches. It is probable that of all the engines named no two could be found so much alike that the parts were interchangeable. One of the rare engravings referred to above is the frontispiece to Count de Pambour's book. Fig. 1 is an accurate reproduction of this engraving. It is one of the very few with a scale. It has been asked how engines with such apparently enormously long chimneys could pass under bridges and through tunnels, certainly with no more head-room than can now be had. But, in point of fact, these old locomotives were very tiny. Thus the distance from the top of the chimney to the top of the rail of the engine we illustrate was only 11ft. 6in. From the rail to the top of the dome is 7ft. 2in. The lower buttons on the driver's waistcoat would be about level with the top of the dome. The driving wheels were 5ft. in diameter; the leading wheels 3ft. 4in.; the wheel base only 5ft.; its length over all 15ft. The wheels had cast iron centres, with wood spokes and felloes. It is difficult to reconcile these small dimensions with the weights which Pambour gives.

The slide valves were put in motion by loose excentrics, which were driven by snugs on the crank axle for going ahead or backwards. There was a gab on the end of the excentric rod which dropped on to a pin in a rocker arm on a short weigh shaft, another arm and pin moving the valve. The valve spindles passed out of the front end of the valve chest. To reverse the engine the driver lifted the gab out of gear, and then shifted the valve by a lever on the footplate and turned on steam, after dropping the excentric rod on the gab pin, which was caught by the gab as soon as it reached it. With these engines De Pambour carried out those memorable experiments that first furnished any adequate and trustworthy information as to what a locomotive engine could and could not do.

De Pambour gives the consumption of fuel and various other particulars. We are able to give facts, however, which are in no way the result of experiments, and they possess a special interest because they show the effect produced on the consumption of fuel by the introduction of the premium system. Our information is derived from the weekly pay sheets of the Liverpool and Manchester Railway in 1840 41. We have selected two, and reproduce them in fac-simile, though to a reduced scale—see Figs. 2 and 3. They show that the average consumption of coke was 23.6 lb. per mile for "coaching" engines, and 37.6 lb. per mile for goods engines during the week ending July 4th, 1840. The sheets are signed by Edward Woods, who, it will be remembered, died not long since at a great age.

It would seem that the premium system was first started during the week ending August 7th in the same year. There is a small reduction in the consumption of fuel, but the loads were smaller. No premium was given to passenger-drivers or firemen. Little information is available as to speeds or weights. But we learn from De Pambour that twenty loaded wagons weighed 88.35 tons, and the tender, full, 5.5 tons. The running time seems to have been about 1 h. 40 min. The first-class carriages in 1835 were called "glass coaches," each carried eighteen persons inside and one out. They weighed 3.65 tons. The second-class carriages were open. They carried each twenty-four passengers, and weighed 2.23 tons. Lastly,

there were "mail coaches" carrying ten passengers, and weighing 2.71 tons. The average load of a wagon was 3.5 tons, while the wagon itself only weighed 1.5 tons. We commend these figures to the modern goods traffic manager.

It is, of course, possible that the loads had increased in the six years between 1834 and 1840, but the same engines were running, with, of course, new additions. In July, 1834, the Firefly, with eight first-class coaches, weighing 36.4 tons behind the tender, ran from Liverpool to Manchester in 1 h. 40 min., from which must be deducted a stop of five minutes, and made the return journey on the same day with the same train in 1 h. 28 min., from which must be deducted in like manner five minutes for a stop. We are told that the Firefly was in "bad order, going to be repaired."

It does not appear that the management had a very definite policy about the premiums. For a little further on we find that they were given to coaching drivers and firemen only; and subsequently they were given to both classes. The amount also varied from 2d. to 12.5d. for luggage engines, 10d. on coaching engines, 4.5d. on bank engines, and 1d. on "jobbing"—by which we suppose shunting was meant—engines. During the week ending 2nd July, 1841, goods engines used 26.6 lb. per mile, the number of wagons being high, as much as 41 for one engine, the Goliath. For the coaching traffic it had fallen to 19.8 lb. per mile, the average number of coaches being under 7. After one or two more trials the premium system seems to have been given up.

These little engines seem to have been extremely well built. While the loads and speeds were small, it must be remembered that the roads were very rough. The following table is taken from De Pambour's book. He writes,

TABLE I.

Work done by the Ten Best Engines of the Liverpool and Manchester Railway during the Years 1831, 1832, 1833, *and the First Twelve Weeks of* 1834.

Year.	Name of the engine.	Total distance travelled by the engine.	Total time the engine has been on the road, either in activity or in repair.
		Miles.	Weeks.
1833	Jupiter	31,582	52
	Ajax	26,164	52
	Firefly	24,879	39
	Liver	23,134	52
	Pluto	20,308	52
	Vesta	19,838	52
	Leeds	19,364	48
	Saturn	18,738	52
	Venus	18,348	52
	Etna	17,763	52
	Sum	220,117	503
	Average per week	438	
1834	Firefly	8,542	12
	Vulcan	8,526	12
	Saturn	7,290	12
	Liver	7,080	12
	Sun	7,080	12
	Etna	6,557	12
	Leeds	5,712	12
	Ajax	4,890	12
	Venus	4,632	12
	Pluto	4,246	12
	Sum	64,555	120
	Average per week	538	

"Among these engines the Liver had worked for 107 weeks, had travelled 52,865 miles, or on an average 494 miles a week during all that time; the Firefly had worked 57 weeks, had travelled a distance of 33,421 miles, or 586 miles a week, and neither of these engines at the period in question had yet required fundamental repair. The statement shows what can be expected from locomotive engines when constructed with care of good materials, and there is no doubt that in time more work will be got out of them." For the year ending June 30th, 1834, the repairs of locomotives cost 0.342d. per ton-mile, passenger and goods trains being included. The total number of passengers was 415,747; the number of trips 6570. This gives an average of 64 persons per train, or, say, 127 trains per week, or nine per day each way.

We have before us profit and loss accounts of the Liverpool and Manchester Railway for the six months ending June the 24th, 1842. These are far too voluminous for reproduction here. The summary, however, which we give in the accompanying tables contains a good deal of interesting information:—

TABLE II.—*Particulars of Locomotives.*

		£	s.	d.
NEW ENGINES.				
Pelican, Ostrich	Nos. 5 and 6	861	8	2½
Owl, Bat	Nos. 7 and 8	1953	0	1
Stork, Crane	Nos. 9 and 10	1092	8	4
Swan, Cygnet	Nos. 11 and 12	928	6	0½
	Nos. 13 and 14	121	19	5
Atlas		224	17	3
		5181	19	4
ENGINES REBUILDING.				
Mastodon		889	12	10
Pluto		847	3	2
		1736	16	0
ENGINES REPAIRING.				
Leopard		82	16	3½
Comet		276	12	11½
Meteor		347	5	7½
		706	14	10½

TABLE III.—*Average Cost per Mile Run.*

	Pence.
Coke	2·24356
Oil	0·42428
Tallow	0·06584
Waste	0·01286
Enginemen and firemen's wages	1·43708
Materials for repairs	0·32583
Wages for repairs	0·39085
Proportion of general charges	3·28562
Total	8·18592

TABLE IV.—*Recapitulation.*

	£	s.	d.
Expended on working engines	4,245	18	1¾
General charges, including water, repairs to pumping engines, coals, firewood, waste and other materials for cleaning, wages for cleaners, enginemen and firemen in the shed, repairs to tenders, salaries of superintendents and clerks, stationery, &c. &c.	2,840	2	11
Total cost of working engines	7,076	1	0¾
Expended on building eleven new engines, per margin ... 5,181 19 4			
Ditto on rebuilding two engines ... 1,736 16 0			
Ditto on repairing three engines ... 706 14 10½			
	7,625	10	2½
Total expenditure	14,701	11	3¼
Total cost per mile run ... 17·07d.			

The average consumption of coke per mile was 20·5 lb., but it is obvious that this refers to engine miles only, not train miles.

It appears that eight new engines were put on the line during the period named at an average cost of £647 13s. 6d. each; we take it for granted that this included tenders. They cost per ton rather more than a modern locomotive. Of coke 1900 tons were consumed, costing £1939, or a little over £1 per ton. The wages paid to drivers and firemen were certainly not excessive. One of the highest rates on the list is under £60, or £10 per month for driver and fireman together. The men were apparently not paid by the week, but by the mile run, or by the time they were actually on their engines.

LONDON AND BIRMINGHAM ENGINES.

We may now leave this, the primitive section of the London and North-Western Railway, and say something of the engines on the far more important section which linked London and Birmingham; but before doing this we desire to point out that the little engines, almost toys, which we have illustrated, possessed every feature of the modern engine. The springs, side frames, horn plates, axle-boxes provide a vehicle as well adapted for high speeds as anything now in existence. The boiler was essentially the same. The draught was got in the same way. The engine had horizontal cylinders and slide valves. The cranked axles, the excentrics, every important member of the modern locomotive, was to be found in these earliest locomotives. The more the facts are examined the more remarkable do they appear; the more fully do they redound to the credit of the Stephensons, father and sons, and the men who carried their ideas into practice.

The line was worked at first by engines in all respects similar to those on the Liverpool and Manchester Railway. In 1840 the directors of the Liverpool and Manchester and Grand Junction Railways, finding traffic increasing, came to the conclusion that improved engines of greater power should be put on the line. Joseph Locke was engineer-in-chief in 1839, and on the last day of that year he concluded a report in the following memorable words:—"If a substantial improvement can be made let it be applied to new engines, or those already worn out which require to be renewed. This is a field sufficiently wide for the most inventive mind, without permitting it to range over the whole list of engines that are in daily use. In making this suggestion I know that it may be said, 'There is an end to improvements,' but so convinced am I of the folly and expense of perpetually altering the engines for the sake of some trifling gain, that I would rather submit to these imputations than see those changes so often made. It would be well also to have in view the advantages of having as many parts of the different engines similar to each other as possible. To give you an illustration, I find that, notwithstanding the great number of engines and tenders, there is sometimes a want of tenders arising from the connecting pipes being of different sizes. I lately found an engine standing idle for the want of a valve to the pump, a small piece of brass, not more than 3lb. in weight, and although there are ten engines of the same class on the line (with two pumps to each engine), there was not one duplicate valve on the establishment. The enginemen should be under the locomotive superintendent, and take their orders from him. In concluding this report, I would take the liberty of pressing on your attention the necessity of preserving with the engines a more uniform rate of speed. All the improvements that experience has suggested, and will suggest, must give way under the effect of over-running. The only way of avoiding this expense is to make a stand at some given speeds, care not how high it is as long as the present engines can do it."

As the loads increased the cylinders were made larger. In 1843 the loads had increased to twelve passenger coaches; the pressure was increased to 60 lb.; the wheels were made 5ft. 6in. in diameter. The new engines had 13½in. cylinders, weighed 12 tons, had six wheels, and took trains of sixteen coaches with clockwork regularity between Birmingham and Liverpool at a speed of thirty miles an hour including stoppages. In 1844 engines were built with 6ft. drivers, and in 1845 some engines were built to work the Lancaster and Carlisle 3hap incline of 1 in 75, with 14⅝ cylinders 20in. stroke, 6ft. wheels, and 75 lb. pressure.

Year after year we find engines of the same type made. The proportions were better, the whole machine was heavier and more powerful; but all the engines had inside cylinders and single driving wheels. Curiously, little attention appears to have been given to the goods engines. They had four-coupled driving-wheels, and a pair of trailers under the foot-plate. The cylinders were inside, and were placed so low down that the crosshead guides were under the leading axle.

The engines on the London and Birmingham Railway differed from those on the Liverpool and Manchester Railway mainly in dimensions. But modifications in type also took place, and coupled wheels were used not only for goods but for passenger engines. An engine called the Comet was the first of a type which has been closely followed. It was constructed for the Newcastle and Carlisle Railway in 1835. Very few drawings exist of the earlier locomotives on the London and Birmingham Railway; but it is known that they differed very little from those on other lines. The elevation of the Comet—Fig. 4—which is reproduced from THE ENGINEER for March 18th, 1881, may be taken as efficiently representing the first coupled engines used on a passenger railway. We possess no particulars as to its dimensions, except that it had 14in. by 16in. cylinders. The boiler barrel was 7ft. 6in. long, and the weight was 8¼ tons. It is noteworthy in that it was the first locomotive with four fixed excentric sheaves and double gab motion. It was built by Hawthorn.

TREVITHICK AND ALLAN.

There is little of importance to record for some few years. The locomotives augmented in size, and more and more resembled the normal inside-cylinder engine of a

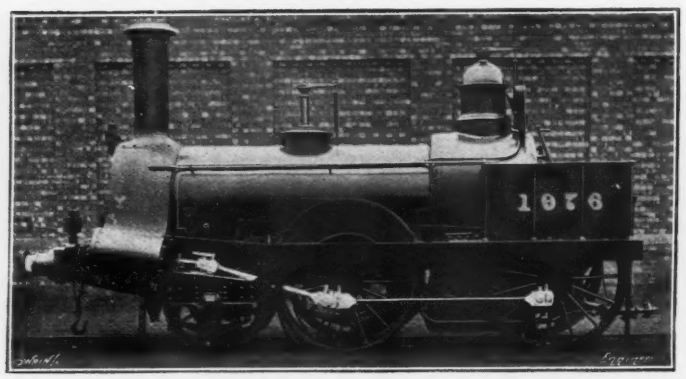


Fig. 5—TREVITHICK'S FOUR-COUPLED EXPRESS ENGINE

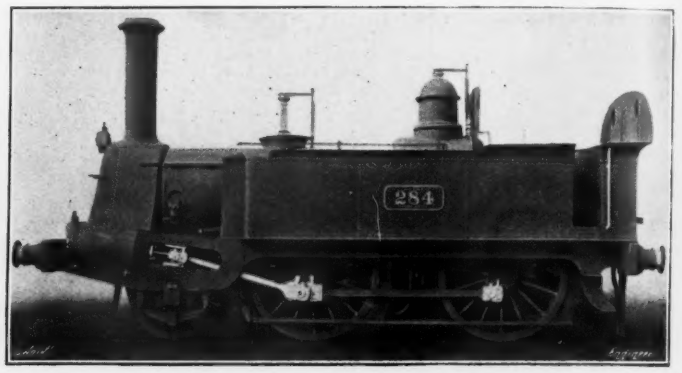


Fig. 6—TREVITHICK'S SIDE TANK ENGINE

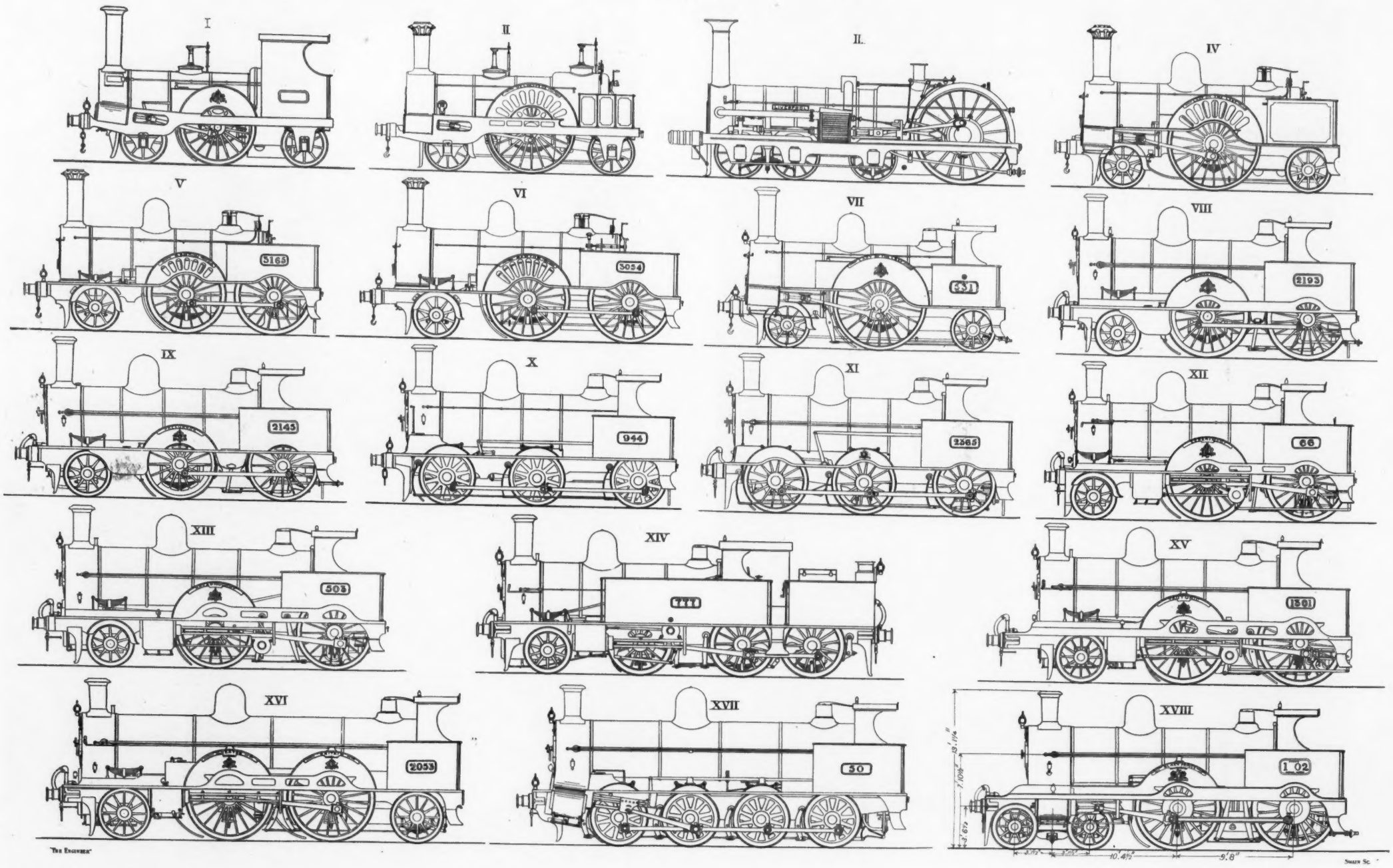
CREWE WORKS

Fig. 7—THE RAIL MILL

Fig. 8—THE BOILER SHOP

DEVELOPMENT OF THE LOCOMOTIVE ON THE LONDON AND NORTH-WESTERN RAILWAY

(See opposite page.)



DEVELOPMENT OF THE LOCOMOTIVE ON THE LONDON AND NORTH-WESTERN RAILWAY

(*See opposite page.*)

I.

TREVITHICK'S PASSENGER ENGINE.—BUILT 1846.

Compounded by F. W. Webb, 1878.

Number of tubes	154
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	765 sq. ft.
,, ,, fire-box	65 sq. ft.
,, ,, total	830 sq. ft.
Grate area	10·78 sq. ft.
Boiler pressure	140 lb. per sq. in.
Cylinders, high-pressure	9in. × 20in.
,, low-pressure	15½in. × 20in.
Diameter of leading wheels	3ft. 9in.
,, driving wheels	6ft. 3in.
,, trailing wheels	3ft. 9in.
Wheel base	13ft.
Total weight of engine in working order	20 tons

II.

ALLAN'S LOCOMOTIVE ENGINE.—BUILT 1847.

Number of tubes	186
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	920·5 sq. ft.
,, ,, fire-box	87·3 sq. ft.
,, ,, total	1007·8 sq. ft.
Grate area	15 sq. ft.
Boiler pressure	110 lb. per sq. in.
Cylinders	16in. dia. × 20in. stroke
Diameter of leading wheels	3ft. 6in.
,, driving wheels	7ft.
,, trailing wheels	3ft. 6in.
Wheel base	13ft. 10in.
Total weight of engine in working order	25 tons 10 cwt.

III.

CRAMPTON'S LOCOMOTIVE ENGINE.—BUILT 1848.

Number of tubes	300
Diameter of tubes	2⅜in.
Heating surface of tubes	2106 sq. ft.
,, ,, fire-box	154 sq. ft.
,, ,, total	2260 sq. ft.
Grate area	21¼ sq. ft.
Cylinders	18in. dia. × 24in. stroke
Diameter of leading wheels	4ft.
,, intermediate wheels	4ft.
,, driving	8ft.
Engine wheel base	18ft.
Total weight of engine in working order	35 tons

IV.

RAMSBOTTOM'S LOCOMOTIVE.—BUILT 1862.

Number of tubes	192
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	915 sq. ft.
,, ,, fire-box	85 sq. ft.
,, ,, total	1000 sq. ft.
Grate area	15 sq. ft.
Boiler pressure	120 lb. per sq. in.
Cylinders	16in. dia. × 24in. stroke
Diameter of leading wheels	3ft. 7½in.
,, driving wheels	7ft. 7½in.
,, trailing wheels	3ft. 7½in.
Wheel base	15ft. 5in.
Total weight of engine in working order	27 tons

V.

RAMSBOTTOM'S LOCOMOTIVE.—BUILT 1863.

Number of tubes	154
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	765 sq. ft.
,, ,, fire-box	85 sq. ft.
,, ,, total	850 sq. ft.
Grate area	13·8 sq. ft.
Boiler pressure	120 lb. per sq. in.
Cylinders	16in. dia. × 20in. stroke
Diameter of leading wheels	3ft. 9in.
,, driving wheels	6ft. 3in.
,, trailing wheels	6ft. 3in.
Wheel base	14ft. 5in.
Total weight of engine in working order	26 tons 2 cwt.

VI.

RAMSBOTTOM'S LOCOMOTIVE.—BUILT 1866.

Number of tubes	186
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	981 sq. ft.
,, ,, fire-box	87·3 sq. ft.
,, ,, total	1068·3 sq. ft.
Grate area	15 sq. ft.
Boiler pressure	120 lb. per sq. in
Cylinders	17in. dia. × 24in. stroke
Diameter of leading wheels	3ft 9in.
,, driving wheels	6ft 9in.
,, trailing wheels	6ft. 9in.
Wheel base	15ft. 8in.
Total weight of engine in working order	29 tons 14 cwt.

VII.

RAMSBOTTOM'S ENGINE.—REBUILT 1876.

Number of tubes	182
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	960·3 sq. ft.
,, ,, fire-box	87·3 sq. ft.
,, ,, total	1047·6 sq. ft.
Grate area	15 sq. ft.
Boiler pressure	140 lb. per sq. in.
Cylinders	16in. dia. × 24in. stroke
Diameter of leading wheels	3ft. 9in.
,, driving whee's	7ft. 9in.
,, trailing wheels	3ft. 9in.
Wheel base	15ft. 5in.
Total weight of engine in working order	29 tons 6 cwt.

VIII.

WEBB'S LOCOMOTIVE ENGINE.—BUILT 1874.

Number of tubes	194
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	960·2 sq. ft.
,, ,, fire-box	103·5 sq. ft.
,, ,, total	1063·7 sq. ft.
Grate area	17·1 sq. ft
Boiler pressure	150 lb. per sq. in.
Cylinders	17in. dia. × 24in. stroke
Diameter of leading wheels	3ft. 9in.
,, driving wheels	6ft. 9in.
,, trailing wheels	6ft. 9in.
Total wheel base	15ft. 8in.
Total weight of engine in working order	32 tons 15 cwt.

IX.

WEBB'S LOCOMOTIVE ENGINE.—BUILT 1874.

Number of tubes	198
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	980 sq. ft.
,, ,, fire-box	94·6 sq. ft.
,, ,, total	1074·6 sq. ft.
Grate area	17·1 sq. ft.
Boiler pressure	150 lb. per sq. in.
Cylinders	17in. dia. × 24in. stroke
Diameter of leading wheels	3ft. 9in.
,, driving wheels	5ft. 8½in.
,, trailing wheels	5ft. 8½in.
Total wheel base	15ft. 8in
Total weight of engine in working order	31 tons 8 cwt.

X.

WEBB'S SIX-WHEELS COUPLED COAL ENGINE.—BUILT 1873.

Number of tubes	198
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	980 sq. ft.
,, ,, fire-box	94·6 sq. ft.
,, ,, total	1074·6 sq. ft.
Grate area	17·1 sq. ft
Boiler pressure	150 lb. per sq. in.
Cylinders	17in. dia. × 24in. stroke
Diameter of leading wheels	4ft 5½in.
,, driving wheels	4ft. 5½in.
,, trailing wheels	4ft. 5½in.
Total wheel base	15ft. 6in.
Total weight of engine in working order	29 tons 11 cwt.

XI.

WEBB'S SIX-WHEELS COUPLED EXPRESS GOODS ENGINE.—BUILT 1880.

Number of tubes	198
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	980 sq. ft.
,, ,, fire-box	103·5 sq. ft.
,, ,, total	1083·5 sq. ft.
Grate area	17·1 sq. ft.
Boiler pressure	150 lb. per sq. in.
Cylinders	18in. dia. × 24in. stroke
Diameter of leading wheels	5ft 2½in.
,, driving wheels	5ft. 2½in.
,, trailing wheels	5ft. 2½in.
Total wheel base	15ft. 6in.
Total weight of engine in working order	35 tons 4 cwt.

XII.

WEBB'S COMPOUND ENGINE.—BUILT 1882.

Number of tubes	198
Diameter of tubes, outside	1⅞in.
Heating surface of tubes	980 sq. ft.
,, ,, fire-box	103·5 sq. ft.
,, ,, total	1083·5 sq. ft.
Grate area	17·1 sq. ft.
Boiler pressure	150 lb. per sq. in.
Cylinders, high-pressure	13in. × 24in.
,, low-pressure	26in. × 24in.
Diameter of leading wheels	3ft. 9in.
,, high-pressure driving wheels	6ft. 9in.
,, low-pressure driving wheels	6ft. 9in.
Total wheel base	17ft. 7in.
Total weight of engine in working order	37 tons 15 cwt.

XIII.

WEBB'S COMPOUND PASSENGER ENGINE.—BUILT 1884.

Number and diameter of tubes, outside	225, 1⅞in.
Heating surface of tubes	1241·3 sq. ft.
,, ,, fire-box	159·1 sq. ft.
,, ,, total	1400·4 sq. ft.
Grate area	20·5 sq. ft.
Boiler pressure	175 lb. per sq. in.
Cylinders, high-pressure	14in. × 24in.
,, low-pressure	30in. × 24in.
Diameter of leading wheels	3ft. 9in.
,, high-pressure driving wheels	6ft. 3in.
,, low-pressure driving wheels	6ft. 3in.
Total wheel base	18ft. 1in.
Total weight of engine in working order	42 tons 10 cwt.

XIV.

WEBB'S COMPOUND GOODS ENGINE.—BUILT 1887.

Number and diameter of tubes, outside	198, 1⅞in.
Heating surface of tubes	1004·5 sq. ft.
,, ,, fire-box	94·6 sq. ft.
,, ,, total	1098·9 sq. ft.
Grate area	17·1 sq. ft.
Boiler pressure	160 lb. per sq. in.
Cylinders, high-pressure	14in. × 24in.
,, low-pressure	30in. × 24in.
Diameter of leading wheels	3ft. 9in.
,, driving wheels, high-pressure coupled	5ft. 2½in.
,, driving wheels, low-pressure	5ft. 2½in.
Total wheel base	21ft. 6in.
Capacity of tanks, in gallons	1400
Total weight of engine in working order	55 tons

XV.

WEBB'S COMPOUND ENGINE "TEUTONIC."—BUILT 1889.

Number and diameter of tubes, outside	225, 1⅞in.
Heating surface of tubes	1241·3 sq. ft.
,, ,, fire-box	159·1 sq. ft.
,, ,, total	1400·4 sq ft.
Grate area	20·5 sq. ft.
Boiler pressure	175 lb. per sq. in.
Cylinders, high-pressure	14in. × 24in.
,, low-pressure	30in. × 24in.
Diameter of leading wheels	4ft. 1½in.
,, high-pressure driving wheels	7ft. 1in.
,, low-pressure driving wheels	7ft. 1in.
Total wheel base	18ft. 1in.
Total weight of engine in working order	45 tons 10 cwt.

XVI.

WEBB'S COMPOUND ENGINE "GREATER BRITAIN."—BUILT 1891.

Number of long tubes	156
,, short tubes	156
Diameter of tubes, outside	2in.
Heating surface of tubes	1381·2 sq. ft.
,, ,, combustion chamber	39·1 sq. ft.
,, ,, fire-box	120·6 sq. ft.
,, ,, total	1540·9 sq. ft.
Grate area	20·5 sq. ft.
Boiler pressure	175 lb. per sq. in.
Cylinders, high-pressure	15in. × 24in.
,, low-pressure	30in. × 24in.
Diameter of leading and trailing wheels	4ft. 1½in.
,, high-pressure driving wheels	7ft. 1in.
,, low-pressure driving wheels	7ft. 1in.
Total wheel base	23ft. 8in.
Total weight of engine in working order	52 tons 2 cwt.

XVII.

WEBB'S EIGHT-COUPLED COMPOUND COAL ENGINE.—BUILT 1893.

Number and diameter of tubes, outside	210, 1⅞in.
Length of tubes	13ft. 4in.
Heating surface of tubes	1374·3 sq. ft.
,, ,, fire-box	114·7 sq. ft.
,, ,, total	1489 sq. ft.
Grate area	20·5 sq. ft.
Boiler pressure	175 lb. per sq. in.
Cylinders, high-pressure	15in. × 24in.
,, low-pressure	30in. × 24in.
Diameter of leading wheels	4ft. 5½in.
,, driving wheels	4ft 5½in.
,, intermediate wheels	4ft 5½in.
,, trailing wheels	4ft. 5½in.
Total wheel base	17ft. 3in.
Total weight of engine in working order	49 tons 5 cwt.

XVIII.

WEBB'S FOUR-COUPLED COMPOUND ENGINE.—BUILT 1897.

Number and diameter of tubes, outside	225, 1⅞in.
Heating surface of tubes	1241·3 sq. ft.
,, ,, fire-box	159·1 sq ft.
,, ,, total	1400·4 sq. ft.
Grate area	20 5 sq. ft.
Cylinders, high-pressure	15in. dia. × 24in. stroke
,, low-pressure	19½in. dia. × 24in. stroke
Diameter of radial truck wheels	3ft. 9in.
,, driving and coupled wheels	7ft. 1in.
Total wheel base	23ft. 2in.
Total weight in working order	53 tons 18 cwt.

few years ago. In 1846 the London and North-Western Railway came into existence by the amalgamation of the Liverpool and Manchester Railway, opened in 1829; the Grand Junction Railway opened in 1837; the London and Birmingham Railway opened in 1838; and the Manchester and Crewe line opened about 1842. The whole system was then divided into two sections, viz., the Northern and Southern division, Mr. Trevithick, a son of *the* Trevithick, being locomotive superintendent of the Northern division; and Mr. McConnell, locomotive superintendent of the Southern division, with Mr. Allan ("Straight Link Allan") as his assistant. In 1856 Trevithick resigned, and Mr. Ramsbottom succeeded him at Crewe. Mr. McConnell left in 1862. The locomotive department was then worked under Mr. Ramsbottom only. He had charge of the whole line. He resigned in 1871, and was succeeded by his principal assistant, Mr. F. W. Webb, who had charge until his resignation in 1903, when he was succeeded by Mr. George Whale, who is chief mechanical engineer of the whole line.

Mr. Trevithick broke new ground by building some very handsome outside-cylinder engines. A controversy at one time existed as to whether they were designed by Allan or Trevithick. Diagram No. I., page vi., shows an engine of this type as rebuilt and compounded by Mr. Webb in 1878. About the engine illustrated by No. II. there is no room for doubt. It was certainly designed by Allan.

Trevithick, in the biography of his father, published in 1872, tells more than one interesting anecdote. Here is one:—"Some twenty years ago"—that is to say, about 1852—"railway competition caused an increased speed in the express trains between London and the North. Frequent notes from the manager urged the locomotive superintendent to actively carry out the wishes of the directors. To do this the superintendent stood by his enginemen on a journey South from Carlisle. At the Lancaster station, when the engineman tested the state of the bearings by a slight touch of the fingers, the leading axle-box caused them to emit the smell of burned skin. Buckets of cold water and some grease were hurriedly applied, and at the guard's whistle the train proceeded. Before many miles had been run the sound of grinding friction gave warning of danger, followed by spurts of blue-and-white flame, with fizzing sparks from the axle-box. Holding out a little longer would bring the train to Preston without loss of time, where another engine was in waiting. The fireman instinctively stood by his brake handle, the engineman with his hand on the regulator watched anxiously the course of events; time was kept. The innocent passengers went on rejoicing; and the directors, almost as ignorant as the public, pursued their policy of hard running. The superintendent, on examining the engine, found that the bearing of the leading axle had been raised to welding heat by friction, causing it to be wrenched from the axle close to the shoulder or nave of the leading wheel; a small roundish knot projecting from the shoulder alone retained it in its place, while the torn-off bearing was imbedded as a solid mass with the fused brass and iron of the axle-box."

The narrative is rather involved, and raises more than one question, as, for example, the relation between high speed and hot axle-boxes, and what it was Trevithick wanted the directors to do. That the three on the footplate should take their own lives in their hands was, perhaps, excusable; but what is to be said of the locomotive superintendent who risked the lives of a train-full of passengers?

SOME HISTORICAL ENGINES.

To Trevithick and Allan the London and North-Western Railway was indebted for all the very hand-

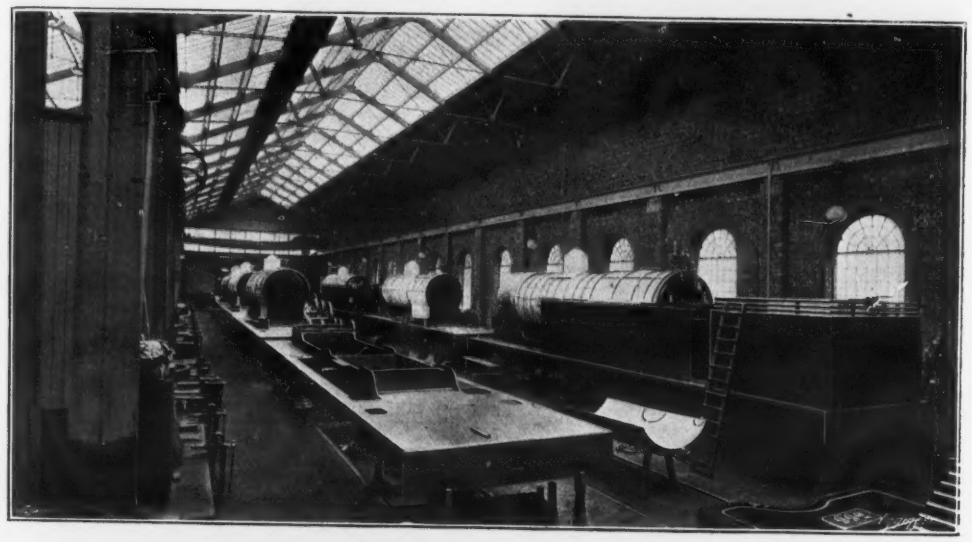


Fig. 9 No. 9 ERECTING SHOP

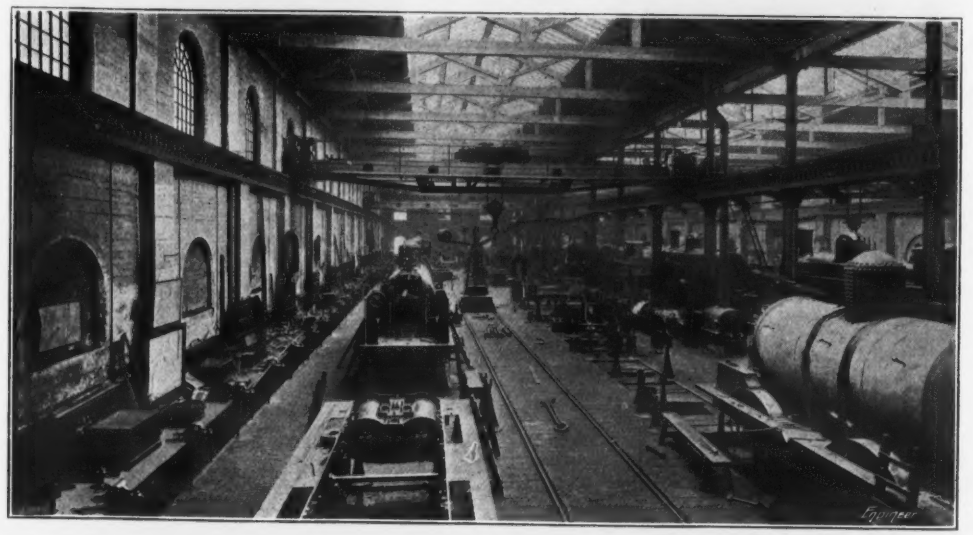


Fig. 10 - No. 4 ERECTING SHOP

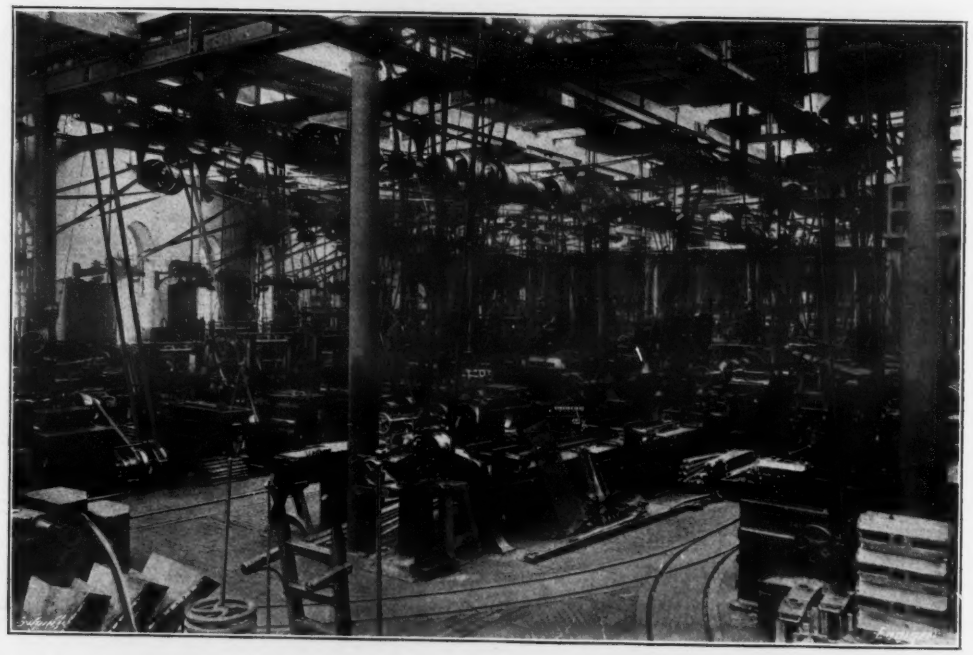


Fig. 11—FITTING SHOP (OLD WORKS)

Fig. 12—THE IRON FOUNDRY

CREWE WORKS

Fig. 13—NEW FITTING SHOPS—CYLINDERS, &c.

Fig. 14—No. 5 ERECTING SHOP

some and efficient outside-cylinder engines of the "Waverley" class, which for many years conducted the mail service between Euston and Holyhead. The most remarkable of these was the celebrated Cornwall, designed by Trevithick, an engine with drivers 8ft. 6in. in diameter, a dimension only exceeded by the 9ft. driving wheels of Pearson's passenger double bogie tank engines on the Bristol and Exeter broad—7ft.—gauge. As originally designed and built in 1847, the boiler barrel was under the driving axle. The engine was a failure, and was rebuilt by Mr. Ramsbottom in 1858. It ran the Liverpool and Manchester 40 minutes expresses from November, 1890, to May, 1902, and from 1858 to 1904 it ran 919,526 miles. No. IV. illustrates the development of the Trevithick-Allan idea. We illustrate as a curiosity the Liverpool, commonly called "the Great Liverpool," designed by Mr. Crampton—No. III. What was known as the "battle of the gauges" raged in 1848. On the one side was Brunel, advocating the 7ft. gauge; on the other, the Stephensons, advocating the 4ft. 8½in. gauge. The former party maintained that the broad-gauge engines must be speedier and more powerful than the narrow-gauge engines. The question was which gauge should be adopted as the national system. Mr. Crampton designed the Liverpool as the narrow-gauge reply to the broad-gauge claims. It was for the time a very big engine indeed; it drew very heavy trains at very high speeds; but it was only in service for a short time, because the permanent way could not carry it. It broke rails almost daily; but it is interesting, because it took the fancy of French engineers, and for many years all the fast trains in that country were worked by engines of the Crampton type, with the driving axle behind the fire-box. So fond was Mr. Trevithick of the outside cylinder engine that he designed two types of goods engine, the one a tender, the other a tank engine, which we illustrate by Figs. 5 and 6. He only built two classes. The first engine, four-coupled, 5ft. wheels, was built in 1852, the cylinders of it were 15½in. diameter by 20in. stroke. Afterwards, in 1856, he built the four coupled side tank engine, also with 5ft. wheels, and cylinders, in the first instance, 15½in. diameter by 26in. stroke, which were afterwards—in November, 1856—increased to 16in. diameter. The weight of the two classes in working order was as under, viz.:—

5ft. Four-coupled Goods.

	t.	c.	q.
On leading wheels ...	6	12	0
,, driving wheels ...	9	14	0
,, trailing wheels ...	6	4	0
Total	22	10	0

5ft. Four-coupled Side-tank Goods.

	t.	c.	q.
On leading wheels ...	7	10	0
,, driving wheels ...	10	0	0
,, trailing wheels ...	10	10	0
Total	28	0	0

It would obviously be impossible to give in detail particulars of all the locomotive types that have been used on the London and North-Western. The various diagrams—Nos. I. to VI.—on page vi., for which we are indebted to the courtesy of Mr. Whale—bring us down to the end of the Ramsbottom period. Between 1851 and 1862 three classes of engines of the same type were designed and built at Crewe by Mr. McConnell; these were known as little Bloomers, big Bloomers, and three extra big Bloomers; they were well-known engines, with inside cylinders and a single pair of driving wheels. They had cylinders 16in. by 24in. and 18in. by 24in., and drivers 6ft. 6in., 7ft., and 7ft. 7½in., according to class. They have been described as fat, heavy, comfortable-looking engines. They have been extinct for many years.

Nos. VIII. and IX. illustrate two somewhat celebrated locomotives, the Charles Dickens and the Precursor, designed by Mr. Webb; while No. X. illustrates his coal engine. These engines, being painted black, were called by the profane "Webb's flying hearses." They did excellent work. They were probably the simplest locomotives ever built in modern days. There was absolutely not a superfluous part about them, and we have been told that their total cost, engine and tender complete, did not exceed £1800 each.

The demand for express fast goods and fish trains brought out in 1880 the type illustrated by No. XI. This class has been found quite suitable for working heavy excursion traffic.

INTRODUCTION OF COMPOUNDS.

Space prevents us from illustrating various types of tank engine designed by Mr. Webb.* We hasten on to deal with the introduction of the compound system by Mr. Webb. He began with an old simple engine with 15in. cylinders. He lined one of these up to 9in., and ran the engine on a branch line between Ashby and Nuneaton till 1883. So far as we know, this was the first compound locomotive tried in Great Britain. He then built, in 1881 and 1882, what was in all respects a new engine—the Experiment, No. XII.—which was rendered possible only by Joy's radial valve gear. He patented the design, which was intended not only to secure economy of fuel, but to get four driving wheels without the use of coupling rods, and also to increase the size of axle bearings and other wearing parts beyond what is possible in an ordinary locomotive. To obtain the advantages just stated, Mr. Webb decided to use three cylinders, viz., two high-pressure of equal size placed outside the frames, and arranged to work on to the back driving axle, and one low-pressure cylinder placed inside the frames arranged to work the front driving axle.

This engine was put to work on 3rd April, 1882, and the results were so satisfactory to Mr. Webb that a number of other engines of the same type were built, but of slightly greater power, the high-pressure cylinders being 13in. diameter, as against 11½in. in Experiment, the low-pressure remaining 26in.

The next type of compound locomotive placed by Mr. Webb on the London and North-Western Railway was the "Dreadnought" class, one of which, Marchioness of Stafford, was exhibited at the International Inventions Exhibition in 1885. In this class the high-pressure cylinders are 14in. by 24in., and low-pressure cylinders 30in. by 24in. stroke, the driving wheels being 6ft. 3in. diameter. This class was designed for working the heavy passenger traffic between London and Carlisle. In 1887 Mr. Webb designed a compound goods tank engine—No. XIV.—the high-pressure cylinders being 14in. and low-pressure cylinder 30in. diameter, both strokes being 24in. The driving wheels were 5ft. 2½in. diameter. The low-pressure piston was connected to the second axle from the leading end, and the high-pressure pistons to the crank pins in the wheels upon the third axle from the leading end. The trailing wheels were the same diameter as the driving wheels, and were coupled to the high-pressure driving wheels. This engine was shown at the Manchester Exhibition in 1887.

In the same year Mr. Webb also brought out a compound passenger tank engine with drivers 5ft. 8½in. diameter; high-pressure cylinders 14in. by 20in., and low-pressure 26in. diameter and 24in. stroke.

The "Teutonic" class—No. XV.—was the next type of compound locomotive introduced on the London and North-Western Railway. This is similar in many respects to the "Dreadnought" class, but has larger driving wheels, viz., 7ft. 1in. in diameter, and low-pressure cylinders remaining the same as in the "Dreadnought" class. A leading feature of this class is the arrangement of valve gear for the low-pressure cylinder, in which all link motion is dispensed with, and in its place a single excentric is used, which is free to turn on the crank axle into the proper positions for forward and backward running. This excentric, which is connected to the low-pressure valve spindle by means of a rocking shaft, is driven by a pin projecting from the side of the crank cheek, and engaging with a slotted plate forming part of the excentric. The system is identical in principle with that of the old Liverpool and Manchester locomotive illustrated on page i. The high-pressure valves are worked by Joy's gear. One of this class, Jeannie Deans, was exhibited at the Edinburgh Exhibition in 1890.

In 1891 Mr. Webb made a new departure in compound locomotive building by constructing an eight-wheeled passenger engine, Greater Britain, which he designed for working the heavy and fast passenger traffic over the West Coast route between London and Carlisle. In this class the high-pressure cylinders are 15in. diameter by 24in., and the low-pressure cylinders 30in. by 24in. stroke. In the former the valves are worked by the ordinary curved link motion arranged inside the frames, and for the latter the single loose excentric is fitted. The driving wheels were 7ft. 1in. in diameter, both being placed in front of the fire-box, this arrangement giving a more even distribution of the weight on the wheels. This disposition of the wheels necessitated a long boiler barrel, which in this case is 18ft. 6in. long. The tubes are divided into two lengths by a combustion chamber, those extending from the fire-box to the chamber being 5ft. 10in. long between tube plates, while those extending from the chamber to the smoke-box are 10ft. 1in. long between tube plates, the diameter in each case being 2⅛in. outside. This chamber is fitted with a steam blast apparatus for clearing the soot out of the tubes. On November 4th, 1891, the Greater Britain ran her trial trip from Crewe to London with a train of twenty-five empty coaches at an average speed of 44.5 miles per hour. Afterwards nine more of this class were built, one of which, Queen Empress, was exhibited at the World's Fair, Chicago.

On December 21st, 1888, that is to say, just twenty years ago, we published as a Supplement the first of the large engravings of locomotives which became and remain a distinguishing feature of The Engineer.

This engraving we reproduce this week. It represents the Marchioness of Stafford, at the time the latest and in many ways the most important addition made to the rolling of the London and North-Western Railway. It was designed according to Mr. Webb's patent, a three-cylinder compound, with two outside cylinders, 14in. diameter and 24in. stroke, and one inside cylinder, with the same stroke, and one low-pressure cylinder, 30in. stroke. The engine was completed on February 25th, 1885. On April 20th following it was sent to the Inventions Exhibition, Kensington, and Mr. F. W. Webb got a gold medal. On November 13th it returned to Crewe, and began regular work from December 17th. between which date and November, 1888, it ran 132,970 miles, with an average load of nine coaches, and a maximum load of sixteen coaches. The consumption was stated to be 36.3 lb. per mile for all purposes, a figure the accuracy of which we do not guarantee.

In 1893 Mr. Webb designed and built an eight-wheel coupled compound goods engine for working the heavy mineral traffic over the South Wales district. The high-pressure and low-pressure cylinders were arranged rather differently from those on other compounds built by Mr. Webb, being placed in a line under the smoke-box, the two high-pressure cylinders being outside and the low-pressure within the frames, all the cylinders driving on to the same axle—the second from the leading end—the two high-pressure cylinders being connected to crank pins in the wheels and the low-pressure cylinder to a centre crank. On April 1st, 1894, trials were made between Crewe and Stafford with this engine, and a non-compound built on exactly the same lines, the wheels in both cases being 4ft. 3in. diameter, to test the capabilities and determine the relative advantages and suitability of compound *versus* non-compound locomotives for working mineral and ordinary goods traffic. In the compound the high-pressure cylinders were 15in. by 24in. and low-pressure cylinder 30in. by 24in. In the non-compound the cylinders were 19½in. diameter by 24in. The results of the trials, which were most carefully carried out, were so largely in favour of the compound that more of the same type were built.

On June 7th, 1895, there were 100 compound engines of various classes built on Webb's system on the London and North-Western Railway, and the mileage run up to that date was 29,847,155.

In 1897 was brought out the latest design prepared by Mr. Webb. This was the Black Prince, a four-cylinder compound, fully described in The Engineer in May, 1898—No. XVIII.—remarkable as the first engine fitted with a bogie which had been used on the L. and N.W.R.

We have refrained from commenting on the merits and demerits of the Webb system, because we are simply recording facts. No more compounds have been built since Mr. Whale took charge at Crewe, but he has effected considerable improvements by duplicating the expansion gear, and thus enabling the driver to adjust the ratios of expansion to the best advantage. All the Webb compound goods engines are gradually being converted into simple engines. Finally, we may say that this brief sketch of the development of the locomotive engine on the London and North-Western Railway might easily have been trebled in length. We have had to rest content with dealing with the more important changes, leaving minor alterations in design unnoticed.

Our account of the development of the London and North-Western locomotives would, however, be incomplete if it were not brought down to date, we therefore illustrate—see plate supplement—three locomotives built from the designs of Mr. G. Whale at Crewe. The first of these is the Precursor, a 4–4 express engine, built in 1904. The cylinders are 19in. by 26in., and the total heating surface is 2009 square feet. The slide valves are of the balanced rectangular type, worked by Joy gear. The working pressure is 175 lb. The locomotive is noteworthy in that it has the first all steel tender used on the line; up to 1904 all London and North-Western tenders had timber frames of Trevithick's design. The driving wheels are 6ft. 9in. diameter. The engine was built to work heavy express traffic between London, Liverpool, and Manchester. It was illustrated in The Engineer, April 8th, 1904.

The second engine, the Experiment, was put into service in May, 1905, that is to say, the following year. It is a 4–6, or "Atlantic" type. The cylinders are 19in. by 26in. The working pressure is 175 lb. There are 299 tubes. The total heating surface is 2041 square feet. The coupled wheels are 6ft. 3in. diameter. This class was specially designed for working the heavy northern section between Crewe and Carlisle. It was illustrated in our impression for October 6th, 1905.

In January last year we illustrated Mr. Whale's latest fast goods engine, 4–6 type, very similar, indeed, in all respects to the engine last described, except that the coupled wheels are only 5ft. 2½in. diameter. The total heating surface is 1984 square feet. The total weight of engine and tender in working order is 100 tons.

The four-coupled compound passenger engine—see plate—King Edward VII., was one of a 4–4 class of forty, the first of which, the Alfred the Great, was made in 1901. These were Mr. Webb's last designs. They had two high-pressure cylinders, 16in. by 24in., and two low-pressure cylinders, 20½in. by 24in. The heating surface was 1508 square feet, grate area 20.5 square feet. Boiler pressure, 200 lb. Driving and trailing wheels, 7ft. 1in. The total weight of engine and tender, in running order, was 89 tons 4 cwt. They would have been the better for larger grates.

MOTOR COACHES.

We have already fully described the motor coach—Figs. 15 and 16—in our impression for September 15th, 1905. The carriage is 57ft. long, and contains two compartments, and seats forty-eight passengers. The whole is carried on two four-wheeled bogies with wheels 3ft. 9in. in diameter. The boiler is of the locomotive type, with 216 tubes 3ft. 3in. long, and 1¾in. diameter outside. The grate area is 6.38 square feet, The heating surface of the fire-box is 41.77; tubes, 275.50; total, 317.27. The total tank capacity is 455 gallons. The bunker holds 16 cwt. of coal. The total weight in running order is 43 tons 8 cwt., of which 27 tons 8 cwt. are carried on the engine bogie, the wheel base, of which is 8ft. 6in., and of that supporting the carriage 8ft. The total wheel base is 46ft. The cylinders are 9½in. diameter and 15in. stroke. The boiler pressure is 175 lb.

EARLY RAILWAY DAYS.

Anything like an accurate history of the working of the first railways would be of very great interest and value. It is possible, but improbable, that sufficient documentary or traditional evidence exists to provide materials for such a history, but the ground is not wholly barren. We may, for example, quote the long series of articles, "Links in the History of the Locomotive," the first of which appeared in our issue for October 20th, 1879. We possess an extremely scarce book, entitled the "Letters of Veritas Vincit" on railway locomotive management, reprinted from the *Railway Record*. The book was published in 1847 by Winnall, High street, Birmingham: but the first of the letters is dated December 26th, 1842. Who "Veritas Vincit" was is as little known as the author of "Junius." It is certain, however, that he knew what he was writing about; that he had a pertinaceous method of getting information, and that he had a most bitter pen. In the present day the *Railway Record* would have wasted its substance in defending libel actions. It would seem that people were not so thin-skinned in those days, or else "Veritas Vincit" had an impregnable case. At all events the correspondence lasted for some years, the last letter being dated June 9th, 1847. The correspondence contains many amusing anecdotes, as, for example, the story of a hunting party who took a special train on the Great Southern and Western of Ireland from Carlow to Dublin. When the train reached the terminus at Kingsbridge they found it deserted, no intimation that a special was coming having been given. Every one had gone home to bed. All the

* Those of our readers who wish for further information will probably find all that they want in "The London and North-Western Locomotives, Simple and Compound," by S. Cotterell and G. H. Wilkinson, published 1899 by the Holland Company, Birmingham.

carriage doors were locked, and the passengers had to get out of the windows. "How fortunate," says "Veritas Vincit," "that there were no ladies in the party." The passengers had proposed to pay on arrival; there was no one to take the money, so they got their special for nothing.

The real interest centres, however, in the methods of working. There was no electric telegraph. There were no fixed signals, no pointsmen—need we add no experience? Why people were not killed by the hundred can only be explained by the fact that comparatively few travelled. "Veritas Vincit" is always fighting the battle of the enginemen against the locomotive superintendents. His first letter is directed against the management of "The North-Midland Railway" from Derby, 73 miles long. He opens his story in the following way:—"The directors of the North-Midland Railway some time ago gave the enginemen and firemen to understand, through their locomotive superintendent, Mr. Marshall, that at the end of the year there would be a reduction. This the men would not accept. But they said that 'they were perfectly willing to serve the company to the best of their power at the present rate of wages and number of working days; that is, 7s. per day for enginemen and 4s. per day for firemen, running the trains three days in each week, and in the shed one day overhauling the engines and resting, running in this manner two weeks and piloting one week.'" We are not told what the men did on three days in each week; we suspect that "three" must be a misprint for "five." What is called "piloting" was arduous work. A pilot engine was supposed to be always under steam, and the driver and fireman had to remain with their engine all night. Fourteen hours was a regular day's work, sometimes it reached nineteen hours. The duty of the pilot was to go to the assistance of engines which had broken down. Not infrequently they made matters worse, especially at night. We gather that tail lights had not been invented in 1842, and on dark nights the pilot sometimes ran into the train it was intended to help. In one case we read of four pilots being sent to help a train in trouble on an incline. They all broke down, and a fifth engine had to be sent to fetch them back again. The system seems to have been something like this: a train was due, say, at Derby at noon. It had not arrived at 2 p.m., then a pilot was sent to look for it. When it was convenient, trains were run for long distances on the wrong line. There is a tradition that two met in this way. The drivers saw each other in time. There was no collision, but who was to go back to the next crossing? Neither would give way, and they settled the matter by bringing their engines together, that which was pushed by the other being defeated. Management and system there was none. It was easy enough to know when a train would start from a terminus; when it would arrive no one could say. The reckless way in which signalling, such as it was, was carried on, was simply astounding. What do our readers think of the following extract from a letter dated Birmingham, March 21st, 1843?—

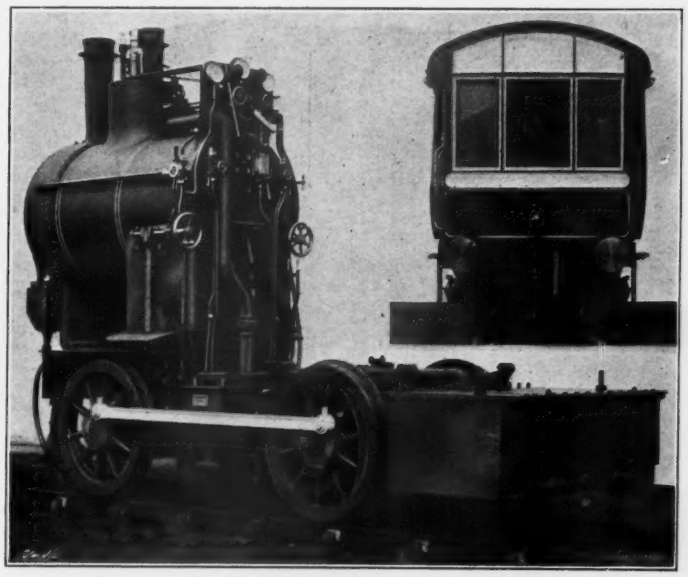


Fig. 15—ENGINE OF MOTOR COACH

"At Clay Cross Tunnel, close by the north end of it, Mr. Stephenson's Coal Railway joins, from which the coal trains get upon the North Midland Railway, and immediately proceed through the tunnel. Formerly there were two watchmen by day and two by night at this end; at the other end there was one watchman by day and one by night, and with this number it not unfrequently happened that, with all their vigilance and care, it was with difficulty they could prevent accident. The above efficient number is now reduced to one watchman by day and another by night, for both ends of the tunnel! I do not know a place upon any railway which requires more vigilance and attention than this particular spot. This tunnel is 1¼ miles long, and rises from the north end of it 16ft. per mile; it is uncommonly wet; the rails are always in a slippery condition, so much so, that when a coal train is heavy the fireman is obliged to have recourse to that frightful risk of standing upon the bufferbar of the engine, and continuing to throw sand upon the rails all the way through, to make the wheels of the engine adhere to the rails, and it is no uncommon occurrence that, with all this, a train comes to a dead stand. Suppose a heavy coal train enters the tunnel, and does come to a standstill, and the watchman's attention is taken up at the other end, the tunnel becomes filled with steam, a passenger train follows, and no signal being given that the tunnel is blocked up (no person being there to give it), the train enters with its accustomed speed, and need I depict to you the awful consequences! The collision takes place; and what could the more fortunate passenger do, who might not be killed, under the excitement, and in a tunnel filled with fire, steam, darkness, destruction, and screams of the most horrid description? It would be next to a miracle if even a single soul were saved to relate the sad event. Is it not the bounden duty of the Directors to take every possible means in their power to increase vigilance at such an important point, to prevent such a scene occurring? The misfortune is, as the law at present stands, if such a disaster were to take place, the Directors would go scatheless."

Sand-boxes had not been invented in those days. Further on we are told:—"When a fatal accident occurs General Pasley, representing the Board of Trade, visits the scene, reports upon it, and gives the directors a caution; they declare there are none more sorry for the occurrence than they, and there the matter drops."

THE FIRST LOCOMOTIVE DRIVERS.

Here is a bit about Mr. Hudson—afterwards the Railway King—and Mr. Cabrey, locomotive superintendent of the York and North Midland Railway. Some enginemen had been discharged. The new men had trouble with the engines, and stated by way of excuse that the discharged men had put oatmeal into the boilers to make them prime. "Veritas Vincit" writes: "Mr. Cabrey must have known that the oatmeal was put in for the purpose of stopping the leaks of the tubes, and not long ago, before the improvement of the fire-boxes and ferruling of the tubes, there was scarce ever an engine sent out without having either oatmeal or bran put into the boiler. What would Mr. Hudson think of putting horsedung into the boiler, which would be preferable to anything else? And I dare say Mr. Cabrey could tell Mr. Hudson that he has put many a bucket full of horsedung into a boiler when he worked the colliery engine in Northumberland." We have here a delightful pen picture of railway boiler engineering in those old days. It seems that much difficulty was experienced in getting drivers and firemen, just as might have been expected. The question has often been asked, who drove the engines on the day the Liverpool and Manchester line was opened. The following extract settles the point:—

"When the work was in progress, Mark Wakefield, Robert Hope, and John Dunn, ballasted with the Lancashire Witch; Thomas George and Robert Creed ballasted with the Twin Sisters; and the reason of there being so many men to two engines was, that the engines were worked night and day; these men were engine-drivers previous to this. At the opening of the line, Mark Wakefield ran the Rocket for the premium against the Sanspareil and the Novelty; Timothy Arkwood ran the Sanspareil; and the Novelty was run by an experienced man appointed by Braithwaite and Co. At the opening of the line for the public, Robert Creed ran the first passenger train with the Northumberland; Thomas George ran the second with the North Star; John Wakefield ran the third train with the Phœnix; and Mark Wakefield ran the fourth with the Rocket. [This last-named engine unfortunately killed Mr. Huskisson.] The other enginemen were John Robson, who ran the Comet; Robert Weatherburn, who ran the Victory (and who ran a trial of strength against Mr. Bury's Liver, which was conducted by Thomas George); Martin Weatherburn, who ran the Mars; Poys Hall, who ran the Vulcan; and Robert Kirkup, who ran the Majestic."

SWITCHES AND POINTS.

The arrangements for working points were to the last degree crude. For economy's sake, in some instances no one was appointed as switchman. For example:—

"From Stretton shunt—a place of almost equal importance with the tunnel—they have removed two switchmen. At this place it is where all the coal trains shunt from the main line, to allow the passenger trains to proceed. Since this change, when the brakesman or fireman of the coal train observes a passenger train coming on—*you must notice they have now a double duty, or, I may rather say, a treble duty, to perform, for they must look out before and behind, and either the one or the other act as switchman*—the brakesman or fireman must leap from the train while at full speed, and shift the points to get off the main line, and if this be not done as quick as lightning a collision cannot be avoided, for there is no one there appointed to run with a signal to stop the passenger train, and should either of those men fall in his leap, fatal results would occur. Is it not unreasonable to impose a duty upon men which is fraught with such imminent danger to themselves, although there were no train close behind them?"

And again:—

"At the Gloucester end of the line there are three switchmen to be discharged—at least they have notice; there are fifteen pair of points to attend to, and when these men are discharged the duty of shifting those points will devolve upon the fireman. As I observed on a former occasion, if the fireman should fall in leaping, what would become of the train of passengers; for on the 12th instant, with the three switchmen, they allowed the engine and tender of the quarter-past eight train to get off the line, and detained it one hour. Even after this lesson it appears that it is intended to do away with this useful class of men.

"At Cheltenham there are not fewer than ten pair of points and no switchman.

"At Ashchurch the day policeman is to be done away with. This is a place of the utmost importance at which to have men placed to watch the trains approaching, for the Tewkesbury branch comes in here, and collisions can be prevented only by the vigilance and activity of the engineman. In foggy weather they must run all hazards of a 'pitch in' occasionally. How will this work with entire strangers?

"At Spetchley day policemen are proposed to be done

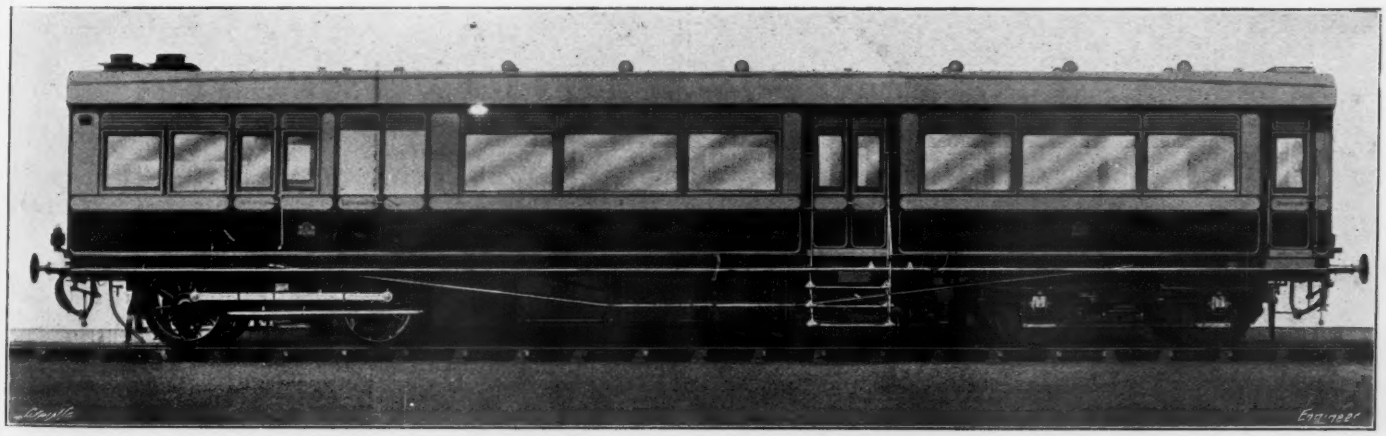


Fig. 16—LONDON AND NORTH-WESTERN RAILWAY MOTOR COACH

away with, and five pairs of points are to be attended to by the firemen.

"At the curve leading to the London junction it is also proposed to remove the switchmen. At this curve there are five pairs of points. Suppose the bank engine were crossing the line at these points, and the fireman off the engine to turn them, and a passenger train coming down that heavy incline at the same time, by reason of the curve the engineman of the passenger train could not see the bank engine crossing. Coming down at full speed he would seldom observe it until he went right over it, and perhaps the whole train would be thrown over the embankment."

It has often been said that Queen Victoria regarded railway travelling with doubt. To the end it is known that she would not travel fast. The foregoing extracts give a clue perhaps to her feelings.

DANGEROUS ECONOMIES.

Some of the side lights thrown on the working of trains is not a little amusing. Thus we are told that at a certain Kingsbury station there was a booking clerk kept at 24s. a week, and also a man at 21s. a week, "to pump water for the engines." But in a fit of economy the man was discharged, and the wretched clerk was told that he must do the pumping as well as the clerking, while his wages were reduced to 21s. a week. Very naturally he said the pay was too low and resigned. Then the porter at the station had to do the pumping. It reminds us of the Bab Ballads. Next we have a serious story:—

"On the 31st December last, at the junction with the Leeds and Selby and York lines, there was a boy—for economy—put on to watch the points. When the mail train was coming from Leeds, the boy held up a white light instead of a red, but fortunately the engineman got a glimpse of the engine coming in the other direction, and was just enabled to stop his train within two yards of the other train coming at full speed. There were only three carriages attached; otherwise they could not have escaped without a dreadful collision. The engineman and both guards declared that they never witnessed so miraculous an escape; the twentieth part of a second and all would have been over.

"About the same time there was another boy in charge of the points at the junction turning off the York line leading to the branch of the North Midland. The weather being foggy, one train was passing across to the branch line, and they had just got across when the other train came up at a tremendous speed. The trains were scarce clear of one another, and the engineman exclaimed: 'That was a narrow escape—we shall have a flare-up some day from these boys.'

"In the month of June last a fitter was sent from Castleford Station with an engine to inform the guard of the York train not to wait for the Manchester train, in consequence of an accident in the summit tunnel. He overtook the train at Burton Salmon Station, and did not shut off his steam until within a few yards of the train, to the terror of the passengers, the greater part of them jumping out of the train upon the other line of rails. Had another train been passing every one of them would have been run over. However, the engine kept coming on until the train stopped, but her speed being lessened no other damage was done but that of jumbling the passengers that were in the train all together, and giving them an additional fright. All this passed over without any further notice having been taken of it beyond the engine-driver getting 'a blowing up' from the station-master, who can bear testimony to the fact."

The foregoing extract leaves us in doubt as to what was the wisest course for the passengers to pursue. Evidently they were second-class passengers who jumped; the others could not have got out. It almost seems that the peccant driver found amusement in "jumbling the passengers" all together. When we remember the habits of the period, we dare not think of the language that must have been used when it was found that no bones had been broken.

THE FIRST FOG-SIGNALS.

We give the following passage, lengthy as it is, because we have here the first mention, so far as we are aware, of the explosive fog signal. A collision had occurred in Clay Cross Tunnel; General Pasley had carried out an inquiry, and reported to the Board of Trade. Commenting on this report "Veritas Vincit" wrote on May 8th, 1844:—

"To return to the case of the engineman killed in Clay Cross Tunnel, and the 'ingenious arrangement adopted on the London and Birmingham Railway, as a fog or danger signal,' noticed in the second paragraph of the General's report, it would appear as if when General Pasley penned the circular he had never given it a thought, that if even 'this ingenious fog arrangement,' as he styles it, had been in use on the North Midland Railway, it would not have prevented the two fatal accidents above alluded to, particularly that in the tunnel, and for this reason:—Suppose the policeman, or tunnel watchman, had been in possession of a hundred of those tin boxes, containing charges of gunpowder, how could he have applied them to the rails before the train entered the tunnel? He was a quarter of a mile distant from his post when the train passed him, and he knew nothing of what had occurred in the tunnel. He was attending to another part of his duty, delivering up passenger-money to the clerk at Clay Cross Tunnel Station—a duty which ought never to have been imposed on him. The real cause of the driver losing his life was that there is not a sufficient number of men at that important place. It is not long since a passenger train ran into a mineral train at this very spot, but, no life being lost, the occurrence was, as a matter of course, looked over.

"It must be very surprising to many of your readers, as it is to myself, that General Pasley should have passed over so silently the condition of locomotive stock. His inquiries must have been made in a very partial quarter, or have been very superficial, for he seems rather to sanction reductions and encroachments on the public safety, in his official capacity as Inspector-General. The only recommendation which is the fruit of his eighteen months' experience is to propose to railway directors—he has no power to compel them—to put in possession of the policemen a number of those exploding tin boxes, to be used by them at discretion! In nineteen cases out of twenty which have occurred during the last eighteen months in which dangerous collisions have taken place these boxes could not by any possible means have been rendered available. This I am prepared to prove; and as to the bringing into practice such a dangerous combustible on railways, I very much question the propriety of the plan.

"If General Pasley had, instead of this tin-box system, recommended to the Board of Trade to apply for more extended powers, so as to be able actually to *prevent* imprudent measures being resorted to, the public would not be jeopardised as it has been on several lines which have come under my review. In place of this, however, he simply gives his sanction to the use of gunpowder to be placed in many hands, that a railway company may be saved a few pounds by reducing an effective, safe, and judicious staff of policemen, and employing incompetent enginemen, as has been so long proved to be the case on the North Midland and other lines. Military or naval gentlemen—a community with which railways swarm—may not be alarmed at a gunpowder explosion, but female passengers, and even not a few male, would not fancy the fragments of a tin box paying them a visit in a carriage. I would recommend to General Pasley and the Board of Trade to reconsider this important matter."

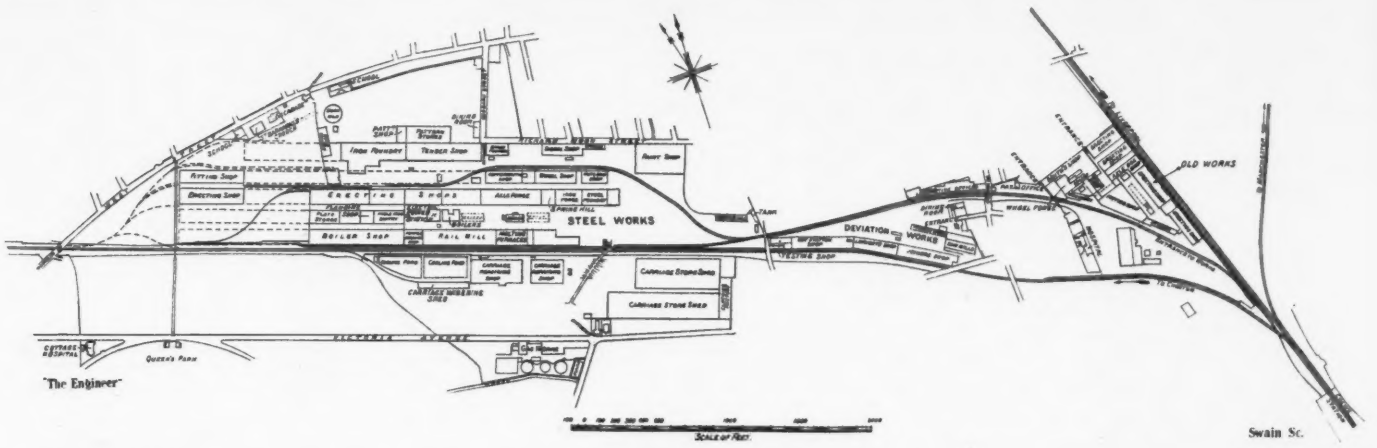


Fig. 17—CREWE WORKS

THE CREWE WORKS.

The Crewe works were established in 1843 during the *régime* of Francis Trevithick as locomotive superintendent, which commenced in 1842 and lasted till 1857. They were originally built with the object of repairing the locomotives, carriages, and wagons for working the Grand Junction Railway, now a part of the London and North Western system. The portion of the works at that time devoted to the use of the locomotive department soon became inadequate to maintain the locomotive stock effectively, and additional accommodation had to be provided by the removal of the wagon department to Ordsall-lane, Manchester. In 1853 a further addition was made to the Crewe establishment by the erection of works for the manufacture of rails. In 1857 an amalgamation of the northern with the north-eastern divisions of the line was effected, and the works at Crewe became the centre of the locomotive and carriage departments of the northern division, while Wolverton became the locomotive centre of the southern division. So fast was the company's stock growing, that in 1859 further accommodation for the locomotive department was required at Crewe, and this was obtained by the removal of the carriage department to Saltley, Birmingham, in the latter part of the year. This was soon after the appointment of John Ramsbottom as locomotive superintendent.

In 1862 it was deemed advisable to combine the locomotive departments of the northern and southern divisions, and Mr. Ramsbottom was appointed locomotive superintendent and mechanical engineer for the whole system. From that time the works at Wolverton have gradually dropped locomotive work and developed the carriage building side, additional accommodation having been provided at Crewe by the erection of suitable workshops. It should be mentioned that the wagon department had been removed to Earlestown in 1853, so that the three branches of locomotive, carriage, and wagon building had now each its own centre. A further important addition to the Crewe establishment followed in 1864, when works for the manufacture of Bessemer steel were erected. This necessitated the acquisition of another site at a short distance down the then Chester and Holyhead line. Hitherto the lines of the Chester and Holyhead Railway had passed through the centre of the works, and, owing to the increasing traffic both in the works and on the railway, it was deemed advisable to divert this portion of the line, so as to place it entirely outside the works. The piece of land situated in the fork between the old line and the deviation was utilised to build additional workshops upon. These are now known as the "Deviation" shops, and are occupied by the millwrights, pattern-makers, and moulders.

In 1870, to keep pace with the continual development of the line, a new boiler shop and smithy were built at the steel works. The engine repairing shops had also been erected here to replace those at Wolverton. In 1874 the tender building and repairing shop and the engine painting shop were removed to larger premises at the steel works. The next step in workshop development was in connection with signals. These had hitherto been constructed and repaired by contract, but in 1881 it was decided to erect a more commodious shop at the steel works, where the whole of the signal work of the London and North-Western Railway is now carried out.

In 1871 Mr. Ramsbottom, to whom the development of the works is mainly due, retired from the company's service, and the late Mr. F. W. Webb, who had been Mr. Ramsbottom's chief assistant prior to 1866, was appointed as his successor. Mr. Webb held the position until 1903, when he was succeeded by the present locomotive superintendent and chief mechanical engineer, Mr. George Whale.

Although the works are chiefly engaged on the building of locomotives, they also produce a large quantity of warehouse machinery and other general machine work, such as is used at the stations. Indeed, so complete are the works, and so wide are the operations carried out in them, that the company is in a position to produce every part of a locomotive from the raw material with the exception of brass tubes and copper plates. The Crewe works at the present time give employment to over 7700 persons, and to these may be added over 700 engine drivers, firemen, and others at the steam sheds at Crewe Station. The company has built and owns 845 workmen's cottages, manufactures and supplies gas, not only to the works but to the whole of Crewe, and supplies water to the works and town. The water is derived from the red sandstone at Whitmore, 12 miles distant from Crewe.

The ground upon which the works stand is about 1¼ mile long, and its area is 137 acres, of which 48 acres are covered with buildings. The works are adjacent to Crewe Station, the most important junction on the company's system, and are divided into three main groups, known as the "Old Works," the "Deviation Works," and the "Steel Works." The plan, Fig. 17 above, shows clearly the general arrangement, but scarcely conveys to the reader the immensity of the largest locomotive works probably in the world.

The general offices are placed nearly central with the entire establishment, their principal front facing towards the works. The façade of the building is 525ft. long and slightly curved On the ground floor are the offices of Mr. George Whale, the chief mechanical engineer and locomotive superintendent, the manager of the works, the running department, the signal and electrical departments, out-station department, and the drawing-office, which is 200ft. long by 30ft. wide. On the first floor are the accountants' office, the stores office, and the labora-

CREWE WORKS

Fig. 18—NEW FITTING SHOP—AXLE-BOXES, &c.

Fig. 19—NEW FITTING SHOP—RODS, &c.

tory and photographic departments. The offices, as well as many of the shops, are lighted throughout by electricity. In the offices incandescent lamps are used, and in the shops arc lamps. A complete telephonic system connects the offices and the whole of the shops, rendering communication over such an immense area easy and expeditious. A fire main, with water at a pressure of 100 lb. per square inch, is provided in that portion of the works where the most inflammable materials are handled. This includes, of course, the joiners' shop, saw mills, and timber yard. There are, in addition, two mains for supplying hydraulic pressure to the machinery in the steel works, one at 400 lb. pressure, and the other at 2000 lb. pressure. Steam is supplied to the engines in the steel works by sixteen stationary boilers 30ft. by 7ft., and by twenty-four boilers of the locomotive stationary pattern. The former work at a pressure of 80 lb., and the latter at 100 lb. pressure, and all the boilers were built at Crewe of Crewe steel. Each of the three main sections has also its own power station, in which electric current is generated and distributed by overhead cables to the different shops. The various parts of the works are connected by a railway 4ft. 8½in. gauge, and there is, in addition, a narrow-gauge line, 18in. gauge, traversing nearly alluded to, the shop is also provided with four 10-ton electric cranes. The shop is well equipped with large radial drills, shearing, punching, tapping and pneumatic caulking tools and plate bending rolls. After being built in this shop each boiler is taken to a testing stand in close proximity, and is subjected to a steam test of half the ultimate working pressure. After successfully passing this test the boilers are submitted to a hydraulic test, the pressure being one-third in excess of the ultimate working pressure. In order to make "assurance doubly sure," a final test is carried out under steam at 5 lb. in excess of the working pressure.

In addition to the purely locomotive work, numbers of stationary and other boilers required for the company's use are built and repaired. Steel girders, both plate and lattice, for warehouses, foot-bridges, &c., are also produced in this shop. As an instance of what can be accomplished in a short time, it may be mentioned that forty-two girders, each 32ft. long, were produced from the raw material in seven days, to replace the Llandulas Viaduct on the Holyhead line, which was washed away by a storm in 1879. It is impossible to allude to the whole of the machine tools in this shop, but Buckton's multiple drill, for boiler end plates, and a milling machine, by Of these Nos. 5 and 6 are used for the repairing of locomotive goods engines, and are each furnished with four 25-ton electrically-driven travelling cranes for lifting engines. Besides these, No. 6 is also provided with a hand-gear travelling crane for lifting wheels, and with four traversers for bringing engines into and taking them out of the shops. The shops are equipped with the necessary tools and plant, such as wheel lathes, drilling, slotting, and planing machines, cylinder and coupling-rod boring machines. For cutting off the ends of boiler tubes in these shops we noticed a handy electrically-driven tool, of which an illustration is given in Fig. 22. The appliance has been in use for some years, and is very simple. It is slung from a portable framework in front of each boiler, and is counterbalanced by weights. A small electric motor drives a spindle, on the end of which is eccentrically mounted a cutter. This cutter enters the tube to a distance which is fixed by means of a loose sleeve shown, and the actual operation of cutting off is done in about half a minute.

Another original tool of a somewhat similar nature is a portable electrically-operated machine for re-boring cylinders of old engines *in situ*. This machine is simply clamped to the flange of the cylinder by two brackets and

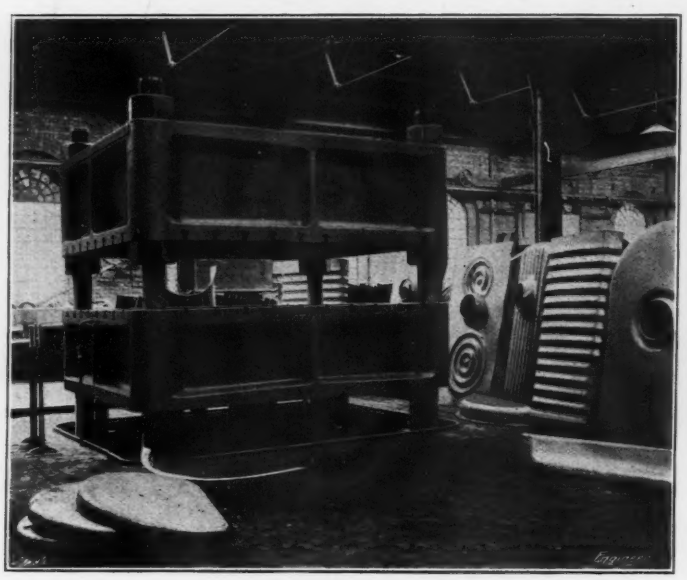


Fig. 20—FLANGING PRESS

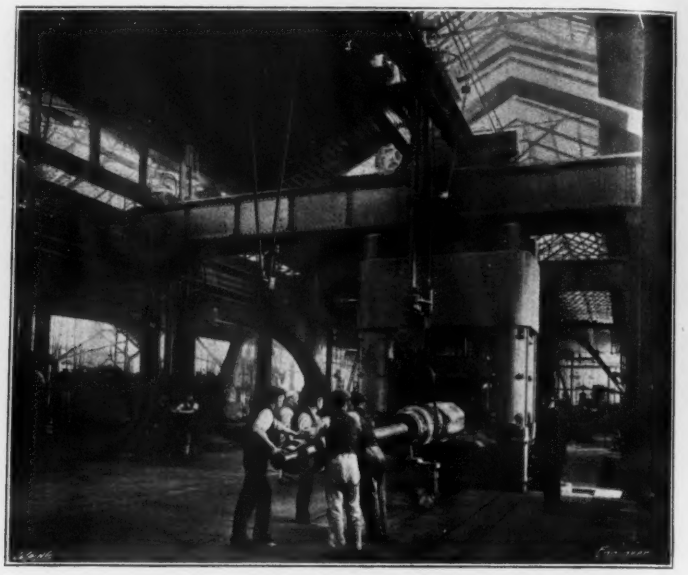


Fig. 21—2000-TON HYDRAULIC PRESS

every part, and of a total length of about five miles. The latter is worked by small locomotives and handy low-wheeled trollies for moving materials.

THE STEEL WORKS.

In the following description of these gigantic works we propose to commence with the steel works section and the raw material. The steel-making plant is capable of producing about 70,000 tons of steel per annum. The Siemens-Martin process alone is now used, and the house in which the plant is contained has seven 25-ton and three 35-ton steel melting furnaces. The gas for these and the reheating and other furnaces is provided by means of 58 Wilson gas producers, being conducted to the various furnaces by underground flues. Each furnace is fitted with powerful hydraulic machinery for lifting and lowering the ladles, into which the molten metal is run prior to being poured into the ingot moulds. The rail ingots are cast 3ft. 4in. long and 14in. square, and after being reheated in reverberatory furnaces are passed through the cogging mill five times, which reduces their section to 10in. by 8in. They are then run directly to the three-high rail mill shown in the illustration—Fig. 7, page v.—whence, after thirteen passes, they emerge as rails 60ft. long and weighing 90 lb. per lineal yard. The cogging mill consists of two cast iron rolls 37in. diameter placed one over the other, and having a series of grooves of varying sizes, the largest at one end being 14in. by 12in., and the smallest 10in. by 8in., as stated above. The mill is driven by a pair of powerful vertical reversing engines, with cylinders 2ft. 6in. diameter by 3ft. 6in. stroke. The rail mill is driven by a Corliss engine of 1200 horse-power. After emerging from the rolling mill with the correct section the rail is passed by "live" rollers at the floor level to a circular saw, where it is trimmed to the required length. It is next taken to a straightening machine and drilling machines. In the latter the holes are drilled at each end for the fish-plate bolts. The rail is now completed and ready for the permanent way. The points and crossings shop is fitted with all the necessary appliances, such as drilling, slotting, milling and planing machines.

THE BOILER SHOP.

The boiler shop—Fig. 8—measures 673ft. by 107ft. 6in. It is equipped with appliances sufficient for building about 200 boilers, and doing the necessary repair work for the boilers of over 3000 engines per annum. Owing to the increase in the size of locomotive boilers in recent years, the roof of a portion of the shop has had to be raised to enable boilers to be slung in a vertical position by 15-ton cranes for the operations of a hydraulic gap riveter. It should be mentioned that nearly all riveting is done by fixed or portable hydraulic machinery. Besides the crane already Beyer, Peacock and Co., for rounding off the corners of copper fire-boxes, are both worthy of mention.

The flanging shop adjoins the boiler shop, and contains some massive hydraulic machinery. Amongst the appliances are three punching and flanging presses by Fielding and Platt, with rams up to 2ft. 6in. diameter, and working at a pressure of 2000 lb. In these presses, one of which is illustrated in Fig. 20, steel fire-boxes, 6ft. 6in. by 4ft., can be flanged at one operation. The total pressure exerted by this press is 650 tons. All locomotive tube and other plates are flanged by hydraulic presses in this

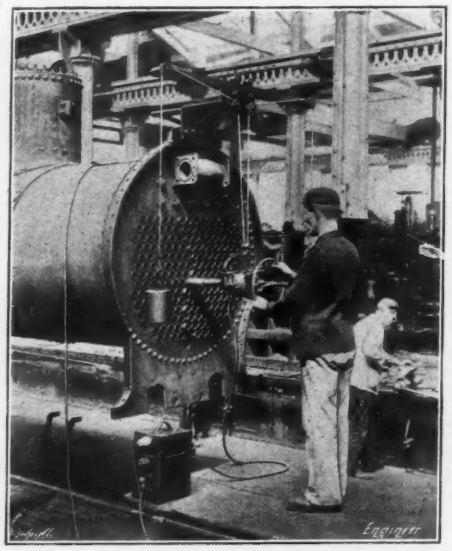


Fig. 22—BOILER TUBE CUTTER

department, and the plates are heated in two gas furnaces. The angle iron smithy also adjoins the boiler shop. In this shop all the forging and stamping operations required for the work of this and other departments are carried out. The shop contains three steam hammers of 7 cwt., 15 cwt., and 30 cwt., a steam welding machine, hot saw, and 60 smiths' hearths.

THE ERECTING SHOPS.

We now come to a group of erecting shops, Nos. 5, 6, 7, and 8, of which some views are given on pages viii. and ix. a small electric motor drives a worm, which in turn operates a worm wheel on the spindle which carries the boring tool. The spindle has a longitudinal motion through a sleeve for the feed, and this is effected automatically also by means of a worm and worm wheel and screw.

No. 9 erecting shop, illustrated on page viii., was built as recently as 1902, and is an ideal building for the purpose to which it has been put. It is excellently lighted by a glazed roof, and warmed to a comfortable temperature in cold weather by hot water pipes placed beneath gratings in the wood block flooring. The shop measures 463ft. long by 110ft., wide, and is used principally for the erection of new engines. At the time of our visit a number of powerful goods engines were in course of erection. A portion of the shop is utilised for repairs to the heaviest types of passenger and goods engines. The shop is equipped with four 40-ton and one 4-ton electrically-driven overhead travelling crane, and the machine tools which are necessary for such a department. In order to accelerate the operation of erecting new engines a frame-fitting stand has been installed upon which the frame plates of each engine are fixed, parallel and true, and all the connecting pieces, such as cylinders, motion and stay-plates, footplates, and hornblocks are bolted and riveted in position. The frames are thus prepared ready for the erecting pits to which they are transferred to receive the boiler, motion, and wheels, &c. At night the shop is lighted by arc lamps.

THE FITTING SHOPS.

A new fitting shop, of which we give several views on pages viii. and ix., adjoins No. 9 erecting shop. It is 463ft. long by 83ft. wide, and contains a wide range of machine tools. These are electrically operated either in groups or separately, according to their size and the nature of their operations. The machines include frame slotting, drilling, and grinding machines; planing, slotting, milling, drilling, and cylinder-boring machines. Two four-ton electric overhead cranes handle the material and pass it from one machine to another. The engine frame plates, as they arrive from the forge, are slotted, drilled, and finished in batches ready to be handed over to the erectors. The radial drills and slotting machines for the plates are chiefly by Hetheringtons, as are also the large frame-plate slotting machines with three heads. The cylinder castings are also brought direct from the foundry into this shop to be bored on electrically driven boring machines made by Greenwood and Batley. The valve faces are milled on Muir's vertical milling machines. Connecting and coupling-rods are milled on their surfaces by means of three Muir's vertical two-spindle milling machines with formers. There are also several of Kendall and Gent's machines engaged on milling out slots in connecting-rod ends;

while Luke and Spencer are the makers of a large grinding machine for finishing piston rods. The pistons of Siemens-Martin cast steel are bored and turned simultaneously on George Richards' well-known vertical machines. An interesting relic, which must be over fifty years old, is a "Jim Crow" planing machine, made by Joseph Whitworth; this has two heads on a cross slide; the tool boxes in these revolve automatically at the end of each draw-cut. It is interesting to compare this machine with a neighbouring modern planing machine of a well-known type, built by Craven Brothers, in which a cut is taken in both directions. The shop is artificially illuminated at night by electric arc lamps, and is warmed in a similar manner to the last-mentioned shop; while all its internal arrangements are the outcome of modern practice.

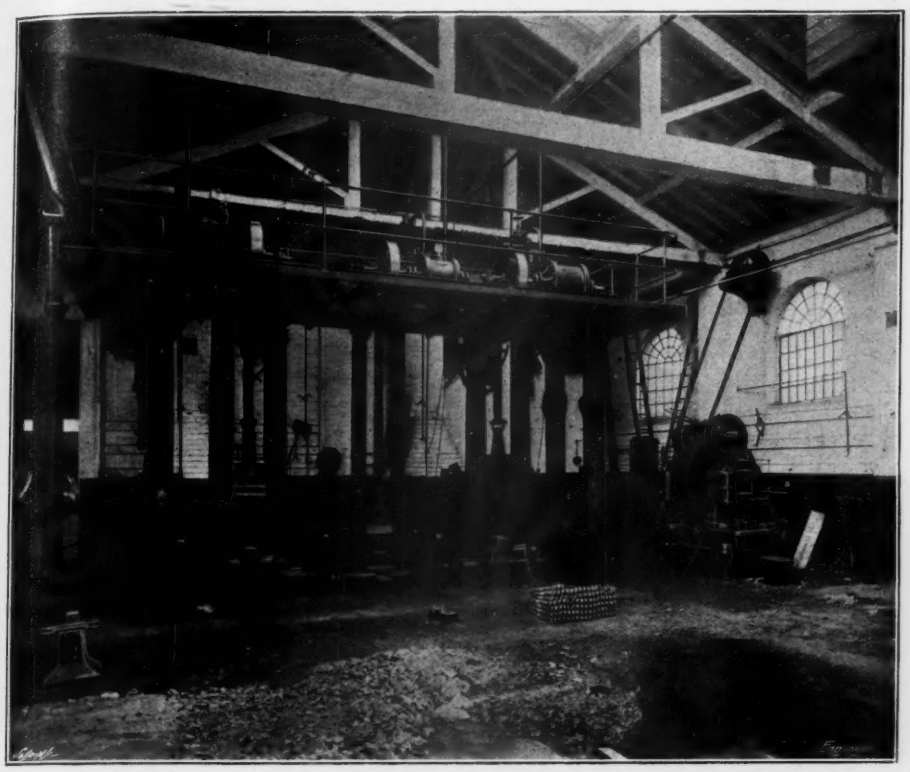


Fig. 23—SET OF DROP STAMPS

THE STEEL FORGE AND FOUNDRY.

We pass now to the steel forge, illustrated in our present issue, which contains some massive tools and plant, including two powerful hydraulic forging presses, one of 650 tons being fitted with an electrically operated "turning-over" gear, which facilitates the manipulation of large steel slabs when under the press; four steam hammers ranging in power from 50 cwt. to 8 tons; one plate and axle mill with four sets of rolls; a tire mill which will roll rings up to 8ft. 9in. diameter; some twenty hydraulic and hand-power cranes, lifts, and hoists; punching and shearing machines and two circular saws, 7ft. diameter, for hot metal. The latter are driven by their own vertical engines, and their velocity at the periphery is said to be in the neighbourhood of 13,000ft. per minute. They are of somewhat crude design, the saw blade being a mild steel disc about ½in. thick, with a cutting edge which is devoid of teeth, but has instead a jagged surface These saws are largely used for cutting up scrap metal, and there is no mistake about the manner in which they perform their destructive duties. All the axles required for the carriage and wagon departments are rolled here, as well as those for the locomotives and tenders, the requisite taper being imparted to them by suitable grooves on the rolls. The plate and axle rolls are driven by a pair of vertical reversing steam engines with cylinders 30in. by 42in. They are quickly reversed by means of hydraulic gear with which they are fitted. The tire mill, too, besides rolling all the locomotive tires, supplies those required for the carriage and wagon department, the latter sometimes numbering 650 per week. The tires are produced in three stages. In the first an ingot, shaped like a truncated cone, is placed in a powerful press and pressed into a small thick disc. In a second operation on the same press a hole is pressed into the ring, while on a third operation, and with the same heat, the centre piece weighing about 13 lb. is pressed out. After reheating, a pair of these rings is then placed on an inverted V-shaped block under a 6-ton steam hammer. This block has a horn on each side, which fits into the centre of the embryo tire. The tup is shaped inside with a form resembling the tread and flange of the tire, and makes a number of blows all round the pair of tires simultaneously, thereby giving them somewhat of their finished shape, and bringing them nearer to their ultimate section. From this hammer the tires are removed to another reheating furnace, and thence to vertical rolls where they are finished in two operations. The spring mill comprises four sets of rolls 14in. and 18in. diameter, driven by a stationary locomotive type engine with two cylinders 18in. diameter and 24in. stroke; a 15 cwt. hammer, two shearing machines, and a circular saw, 3ft. 6in. diameter. The iron forge is fitted with a merchant mill, with five sets of rolls, driven by a pair of horizontal engines; three steam hammers, 5 tons, 3 tons, and 30 cwt. respectively; three shearing machines, hydraulic and hand cranes, and a circular saw.

The steel foundry measures 300ft. by 75ft., and contains three 10-ton steel melting furnaces, and the necessary hydraulic machinery for manipulating the ladles. There are several travelling cranes capable of lifting up to 10 tons, and jib cranes, revolving hydraulic tables on which wheels are cast, and axle-box moulding machines and drying ovens. This foundry is capable of turning out 40 tons of steel castings per week. The nut and bolt shop, or "the nursery," as it is called in the other shops, has the usual machine tools to be found for the class of work done in it. These include lathes, shaping, and slotting machines, bolt and nut forging machines, nail and sprig making machines. All of these are driven by means of a duplex gas engine. Nearly all of the machines are operated by lads, hence the nickname "nursery."

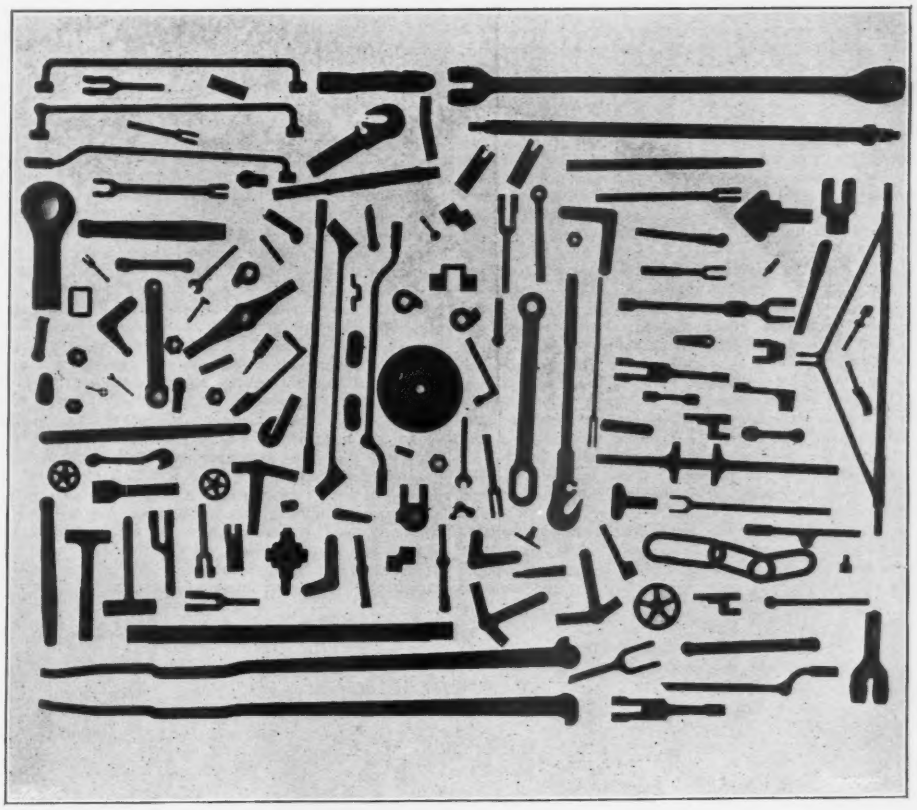


Fig. 24—DROP STAMPINGS

VARIOUS SHOPS.

The wheel shop contains some very powerful machine tools. There are wheel lathes for turning up to 9ft. diameter, axle and tire lathes, slotting, planing, boring and milling machines, frame and piston-rod grinding machines. A powerful crank "nibbling" machine for roughing out the crank pins of solid crank axles has a tool holder carrying as many as 160 cutting tools at once. The crank after being "roughed down" in this machine is annealed, then put into a lathe for a further roughing operation, and is afterwards finished in another lathe. Mr. Whale's engines have all built-up crank axles, the journals and crank pins being shrunk and keyed into the balanced webs. The wheel shop also contains hydraulic presses for putting on and taking off wheels, putting in crank pins, &c., while for handling the heavy articles there are two 4-ton electric travelling cranes. The machinery is driven by two gas engines, each of 30 horse-power.

The remaining shops in the steel works section include a coppersmiths' and tinsmiths' shop, in which are made lamps, buckets, boxes, and sundry other articles required in the locomotive department. *A propos* of boiler tubes we noticed a neat method of securing copper ends on to steel tubes, which are now finding favour among locomotive engineers. The steel tube is bored out taper at its ends, and the copper end pieces are turned down to a corresponding taper. Between the two is inserted a strip of brazing metal, and the whole is then placed in a brazing furnace. The result is a perfectly sound and strong joint. An adjunct to this shop is the galvanising department, where tender and tank plates are dipped in baths of molten zinc. There also remains an ironfoundry, of which an illustration is given on page viii. This contains seven cupolas with capacities from 2 tons to 30 cwt. The pig iron, coke, &c., required for the larger ones are raised bodily in the wagons in which they come to the works to a platform about level with the cupola mouth. This is effected by a hydraulic hoist. The other plant consists of two 10 ton electrically-driven travelling cranes, numerous hydraulic and hand cranes, wheel, cylinder, and other moulding machines. The building measures 462ft. by 121ft. Adjoining it is a smaller foundry, devoted entirely to the casting of rail chairs. This is done entirely without machines. The pattern shop and stores adjoins the foundry.

The tender shop is one of the finest of the whole establishment, and measures 530ft. by 121ft. Besides the building and repairing of tenders, the construction of tanks for engines is also carried out here. The shop is fitted with six 6-ton electrically-driven travelling cranes, electrically-driven wheel lathes, drilling, shaping, punching, and shearing machines. The brass foundry contains no special features, but it should be stated that machine moulding is resorted to for certain classes of work, the Tabor machine being used.

The signal shop is 280ft. long by 85ft. wide, and produces the whole of the signalling apparatus used on the London and North-Western Railway. It contains a number of machine tools, such as lathes, drilling, planing, and screwing machines, saws, general joiners, &c., all of which are driven by a gas engine. The paint shop measures 350ft. by 208ft., and has a roof of the weaving shed pattern arranged to give a north light. It is warmed throughout, and will hold more than 100 locomotives.

The power-house for the steel works contains eight Belliss and Morcom 135 horse-power compound steam engines

direct coupled to continuous-current dynamos. These generate current at 120 volts for the power circuit. There are also three Willans and Robinson's compound steam sets with dynamos supplying current at 600 volts for the arc lighting, the lamps being arranged twelve in series.

THE DEVIATION WORKS.

We shall now pass on to the group of shops known as the "Deviation Works," the situation of which will be seen on the plan given on page xii. The first shop we pass through is one of considerable importance, as upon it depends to a very large degree the safety of some millions of the travelling public. We allude to the testing shop. In this are tested pieces of all the steel plates used in the construction of the boilers. The tests are severe. Strips of metal are first punched with a ⅞in. hole, which is then drifted out to a diameter of 2in. Other strips are bent double. Both of these tests are made on the cold plate, and every plate that does not satisfy the tester is rejected. The plates are also subjected to tensile tests and analysed for carbon. The tensile test is carried out on a Whitworth machine. A test piece treated under our supervision gave an elastic limit of 19 tons, and a breaking load of 30.88 tons per square inch. Records of all tests are carefully kept in a book for the purpose. All chains for cranes and other purposes are made in a smiths' shop adjoining the testing shop, and are tested before going out of the works, as are also all engine and tender couplings. The tests are not confined to new chains, for all chains in use are brought into the shop at least twice a year, and are tested to eight times their working load. Ropes, too, are tested, and are required to withstand a stress equal to 2.3 times their working load. The plant for testing comprises one of Tangyes' hydraulic chain-testing machines for working up to 45 tons, one of Buckton's 50-ton tensile testing machines, and a 100-ton tensile testing machine built at Crewe.

The millwrights' shop comes next in rotation. In this department no kind of engineering work comes amiss, and slackness is unknown. Here the building of stationary, steam, and pumping engines, cranes, dynamos, gas compressors, and the *olla podrida* of a huge railway system is carried out. The plant consists of four 10-ton electric travelling cranes, one 30-ton electric crane, and numerous lathes, drilling, slotting, planing, boring, screwing, and file-cutting machines. There is also a steam sand blast apparatus for sharpening files. An electrical department in the gallery is devoted to the smaller electric fitting work.

The remaining departments of the Deviation works are devoted chiefly to the working and treatment of timber. In a large joiners' shop equipped with wood-working appliances of all kinds the roofing, doors, windows, and sheds which are used in large quantities, are prepared. The tools are chiefly by Ransomes and Greenwood and Batley, and are driven electrically. Some idea of the extent of the work carried out may be obtained from the fact that over five million superficial feet of timber are cut up and used per annum. A large saw mill adjoins the shop. In this are made the oak keys for securing the rails in their chairs. After being cut up to their requisite length and section the keys are all "steamed," an operation which is necessary to drive the sap out of the timber. The keys are delivered automatically from the saws into large tanks capable of holding each about 30,000. The tanks are mounted on trunnions, and after steam has been admitted for a period of about eight hours, the covers are removed, and the keys are discharged into revolving cylinders containing powdered graphite.

In these chambers the keys are caused to revolve for a period of about twenty minutes. They are next placed in a machine having steel dies, through which they are forced, thus securing a uniform and accurate section. From this machine, again, the keys are passed through a pipe into wagons by which they are conveyed to the stores.

The power station for the deviation works comprises three Babcock and Wilcox boilers, two of which are coal-fired and one fired by wood refuse. These boilers supply steam for six 125 horse-power Bellis and Morcom engines and dynamos, and one 100 horse-power Bumsted and Chandler steam set. Current is generated at 120 volts pressure, and there are two separate circuits for power and lighting purposes. A number of accumulators are provided in an adjoining room for supplying current for lighting when the engines are not running.

Two of the power houses are provided with Paterson's oil eliminators with make up softening gear. In this apparatus the greasy condensed steam enters a measuring chamber quietly, and overflows through a vertical slit which is made long and narrow so as to produce a maximum rise and fall in the water level. In adjoining compartments two long tapered valves controlled by a float discharge the weight of re-agents in accurate proportion to the water passing through the slit. The bulk of the coagulated impurities is arrested by filtering upwards through wood fibre, but the final purification takes place in a quartz sand filter. The filtered water flows into an inspection box, whence it overflows into the feed tank. The make-up supply to be softened is controlled by a float in the latter tank.

Fig. 25—HOSPITAL AT CREWE WORKS

THE OLD WORKS.

We come next to the section of the establishment known as the "Old Works." These embrace a forge, smithy, spring shops, several erecting shops, a fitting shop and stores. In the forge the principal work consists in producing the forgings required for the locomotives and general work. In addition to the necessary furnaces there are five of Brett's steam hammers ranging in power from 7 cwt. to 50 cwt, and ten of Brett's drop hammers ranging from 8 cwt. to 30 cwt. A group of these is shown in Fig. 23, page xv., and a group of engine parts produced by them is shown in Fig. 24. The stamping work done by the drop hammers is quite a special feature of this department, and reflects the highest credit upon the manager. Practically all parts of the motion work of the locomotives are now produced in the form of stampings, and the cost compared with hand forging shows a very great economy, while in the matters of speed and accuracy of finish the drop stamps are easy winners. We have seen nothing better of the sort. The smithy which adjoins the forge is fitted with nine steam hammers from 7 cwt. to 15 cwt. There is also a Thompson electric welder of about 40 horse-power which is in constant use. In the smithy and forge there are altogether 117 smiths' fires. The spring shop contains a number of hydraulic machines, comprising knibbing, punching, bending, buckle squeezing, and testing machines. The power for operating these is derived from two special sets of pumps and accumulators working at 1800 lb. per square inch.

No. 4 erecting shop, an illustration of which is given on page viii., Fig. 10, was originally reserved for the building of new engines, but is now devoted entirely to repairs. It has four 25-ton electrically-driven overhead travelling cranes, and the other appurtenances of an engine erecting shop. This shop has taken a share in the making of locomotive history, for it has turned out a large number of noteworthy engines. There is, for instance, the "Charles Dickens," 6ft. 6in. four-coupled; "Experiment," 6ft. 6in. compound, the first compound engine designed and built to Mr. Webb's designs; "Marchioness of Stafford," 6ft. compound six-wheels engine; "Jeannie Deans," 7ft. compound six-wheels engine; "Greater Britain," 7ft. compound eight-wheels engine; "Queen Empress," another engine of the same class; and many other celebrities amongst locomotives. No. 1 erecting shop, with its old gateway and clock tower, is noteworthy as being one of the first buildings erected when the works were established in 1843. It is now chiefly used for repair work. Motion shops and a large fitting shop complete the group of shops forming the "Old Works." The fitting shop is illustrated in Fig. 11, page viii., and by two views in our current issue. It contains a great many machine tools electrically operated in groups. The tools include a number of Herbert's capstan lathes, grinding machines for trueing-up pistons and piston-rods, &c. Most of the numerous details of locomotives, such as pistons, valves, connecting and coupling-rods, injectors, and brass-work, are turned out of this department, all being finished to standard gauges and templates. The fitting shop has its own tool shop, and adjoining it is the finished stores, from which no articles can be withdrawn without a signed order from a foreman to the store keepers.

The power station for the Old Works comprises three Lancashire boilers working at 175 lb. pressure, fitted with Erith's underfeed stokers; five compound steam dynamos of 240 horse-power each, by Belliss and Morcom, and the Lancashire Dynamo Co. These supply current at 650 volts. The power-house also contains condensing plant and Edwards' air pumps. In order to deal promptly with the accidents which it is impossible to avoid in industrial establishments employing such a large number of workpeople, an infirmary is a necessary adjunct. The London and North-Western Railway Company has made ample provision for such mishaps. The admirable hospital, which is illustrated on this page, comprises three comfortable wards, each containing eight beds, an operating room with the most modern surgical appliances, and the Röntgen rays. The hospital is presided over by a skilled surgeon and two male nurses, and is in telephonic communication with all parts of the works.

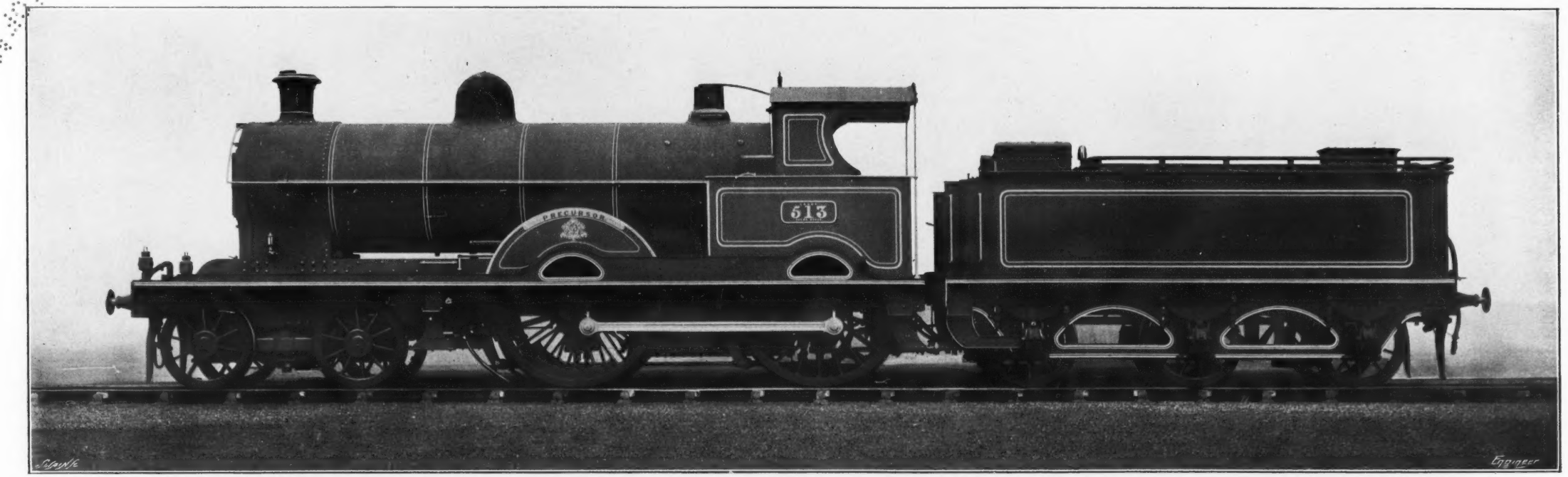
CONCLUSION.

Altogether 4811 engines have been built at Crewe up to date, and the total stock of locomotives in use at the end of October last was 2969, comprising 954 passenger engines and 2015 goods engines. An idea of the capacity of the shops and the growth of the London and North-Western system may be formed from the following:—The 1000th engine was built in December, 1866; the 2000th in June, 1876; the 3000th in July, 1887; and the 4000th in March, 1900. The usual time taken to build an engine is about four weeks, but as an experiment and with a view to testing what could be done in an emergency an engine has been erected between 6 a.m. on Monday morning and was finished, in steam, and ready to work by 1 p.m. on the following Wednesday, or 25½ working hours.

We are indebted to Mr. G. Whale for the excellent photographs from which our illustrations are produced, and also for providing us with facilities for obtaining the foregoing information; and to Sir Frederick Harrison and Mr. C. E. Grasemann for assistance in the preparation of the coloured supplements.

RECENT LOCOMOTIVES ON THE LONDON AND NORTH-WESTERN RAILWAY

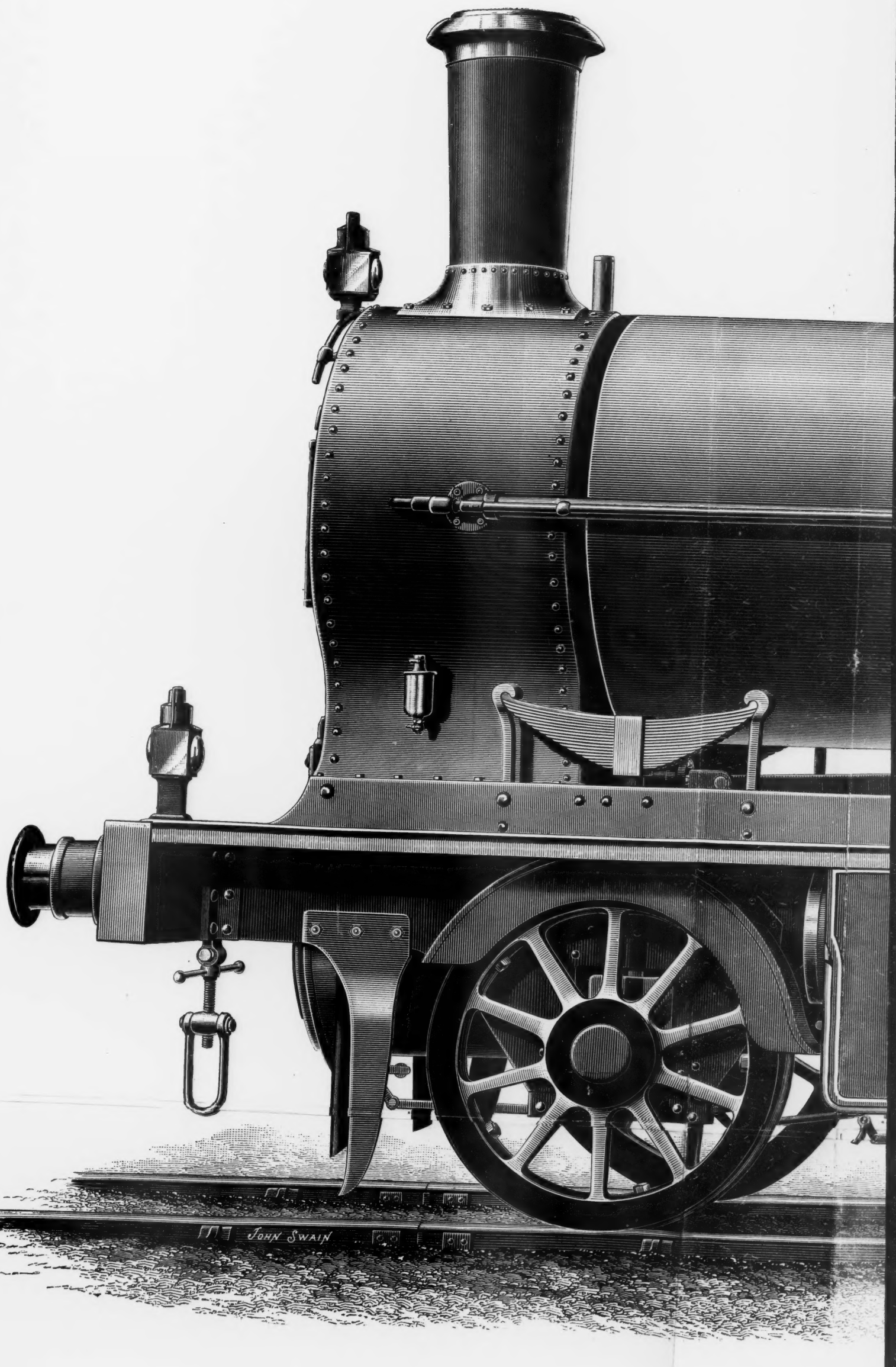
MR. GEORGE WHALE, M. INST. C.E., CREWE, ENGINEER



FOUR WHEELS COUPLED EXPRESS PASSENGER LOCOMOTIVE—PRECURSOR

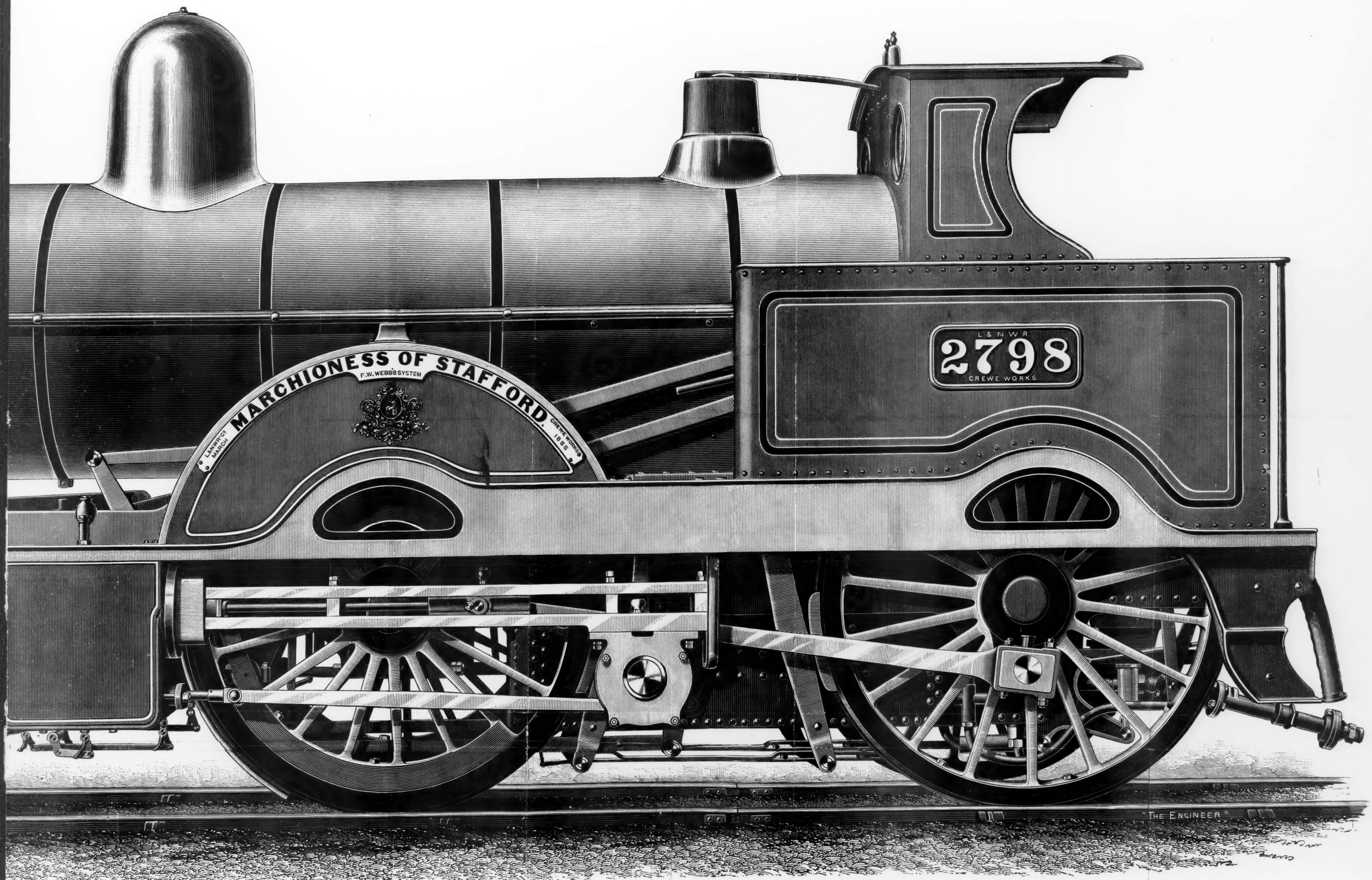
FOUR WHEELS COUPLED COMPOUND EXPRESS PASSENGER LOCOMOTIVE—KING EDWARD VII.

SIX WHEELS COUPLED EXPRESS GOODS ENGINE


JOHN SWAIN

COMPOUND EXPRESS LOCOMOTIVE, LONDON AND NORTH-WESTERN RAILWAY

MR. F. W. WEBB, M. INST. C.E., CREWE, ENGINEER



"THE ENGINEER"

PUMPS FOR DRAINING THE KILSBY TUNNEL

HEAD GEAR, GREAT SHAFT, KILSBY TUNNEL.

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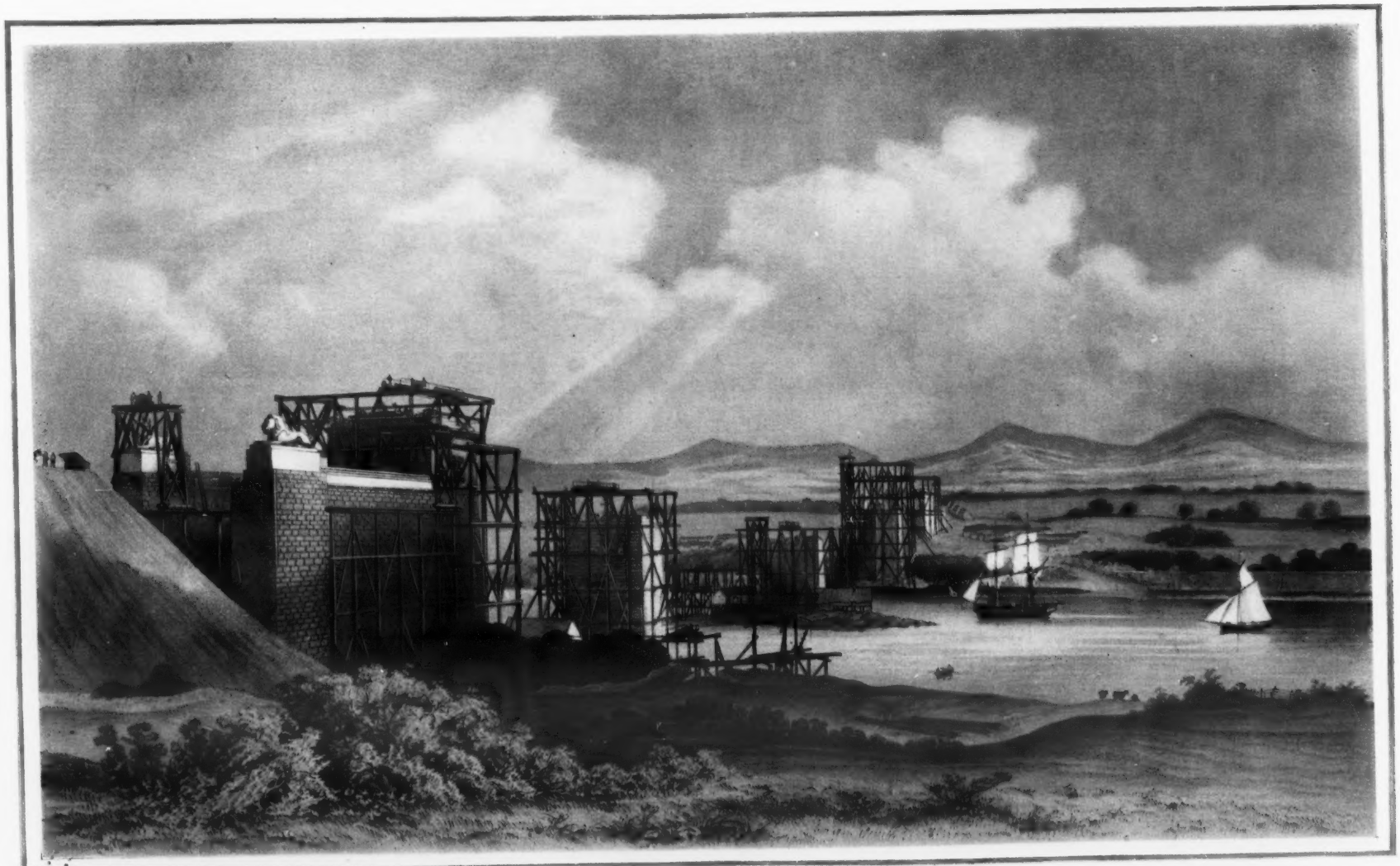
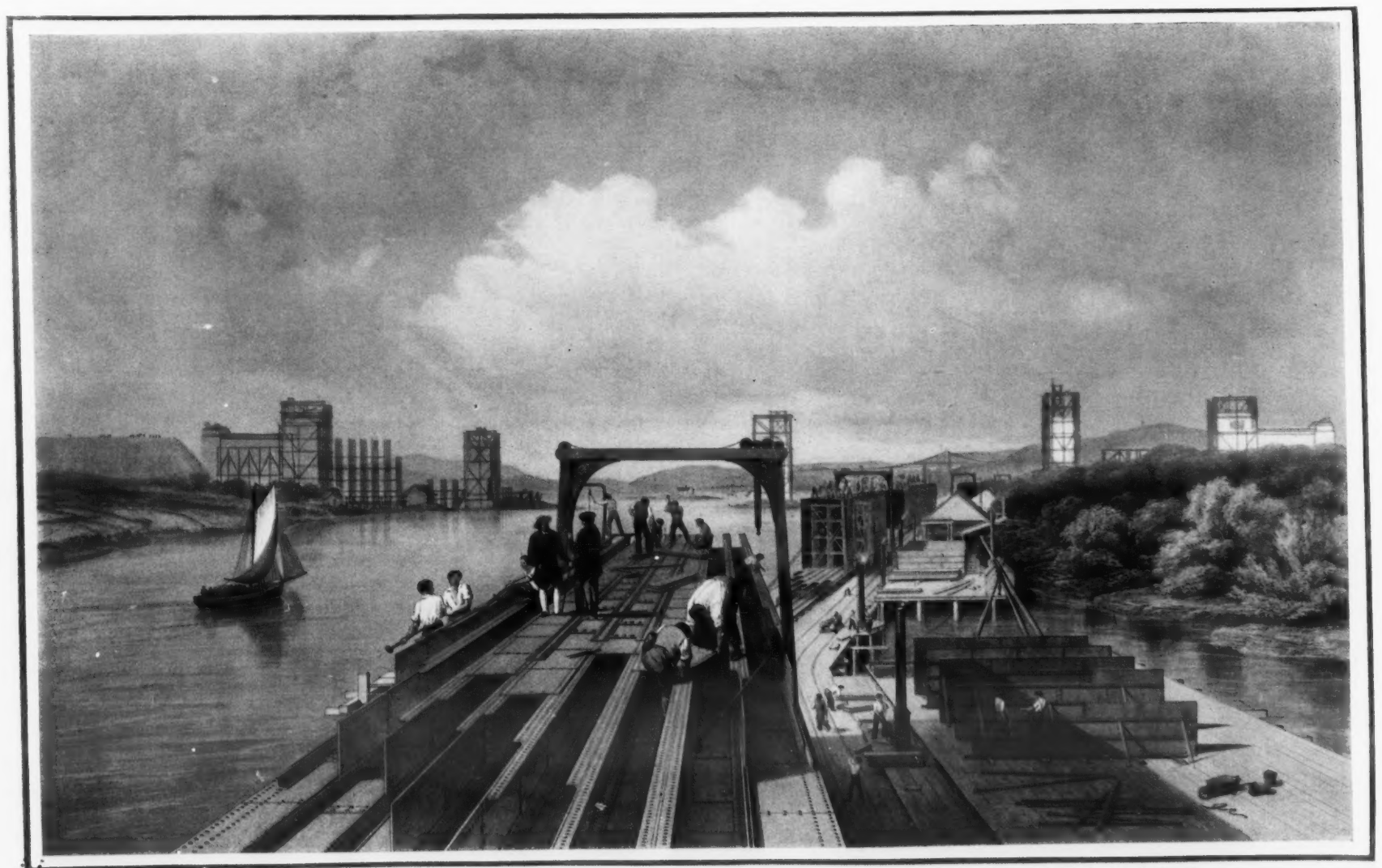


BRITANNIA TUBULAR BRIDGE OVER THE MENAI STRAITS

TAKEN DURING ITS CONSTRUCTION IN 1848.

Robert Stephenson Esqr. M.P. Engineer

Bull, Austin & Co., Ltd., London, Imp.



BRITANNIA TUBULAR BRIDGE OVER THE MENAI STRAITS.

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FRANCO-BRITISH EXHIBITION—GRAND PRIX—HIGHEST AWARD OBTAINABLE.

THE GERMAN INSTITUTION OF NAVAL ARCHITECTS.

No. III.*

AT the recent meeting of this Institution a paper entitled "Technical and other Considerations in regard to the Placing of the Lifeboats in Modern Vessels," was read by Mr. Axel Welin, of London. It contained a new proposal for the solution of the ever-increasing difficulties connected with the lofty situation of the boats in large passenger vessels, and proposed that in future they should be removed from the upper promenade deck to a much lower position, whence they could, in case of a catastrophe, be put into the water with much less danger, and where they could also be more easily reached by the passengers. Pictures were shown illustrating the plan as applied to boat arrangements worked by the familiar Welin "Quadrant" davits.

The next paper read was on "Transporting Plant for Building-slips," by Herr Michenfelder, of Düsseldorf.

After some introductory remarks on the fitting up of building-slips during the last few years with the many systems of mechanical transportation which the German yards in particular have adopted, the author proceeded to discuss the working arrangements and economical considerations which justified the use of the various lifting appliances and aërial ropeways in shipbuilding. With the help of a large number of illustrations, he discussed the advantages and disadvantages of the various systems, beginning with the primitive derricks, and showing their gradual improvement till they developed into the distinctively German arrangement—the revolving tower crane. Next to the elevated revolving cranes and to the unpractical derrick trestle cranes mounted on high framework, which were shown to be in extended use in the United States and in England, the lecturer gave most attention to a discussion of the different combinations of travelling cranes arranged above the building slips. These were the dearest type, but they were adopted in the majority of the recent extensions of the large German shipyards on the North and Baltic Seas as the most advantageous means of transport, and it was considered that their use rendered possible a rapid, independent and rational system of working in the building berths in a much higher degree than that of the appliances last mentioned. The author then gave particulars of various designs, worked out by well-known German engineering firms, and made certain proposals of his own, after which he went exhaustively into the question of aërial ropeways as applied to building berths. As in the case of the crane arrangements, Herr Michenfelder here also credited his own countrymen with having produced the most practical appliances of their kind for transport purposes on the building slip.

In opening the discussion, Geheimer Marine Baurat Brinkmann said the German yards had made a long step in advance with the tower cranes; for the American arrangements could not be compared with them. The value of the German cranes lay in the circumstance that as slips increased in breadth the crane tracks could be simply moved outwards. A drawback which was attributed to the tower cranes was the considerable amount of room that they took up. That had to be conceded; they required a gauge of at least 21ft.; but when their substructure was left open the ground beneath could be used to lay material on. The portal of the first dockyard crane had been so dimensioned that a locomotive could pass through it; the material could thus be brought to the crane, which was a natural and economical arrangement. Two tower cranes were sufficient for all purposes. In the case of the battleship Nassau, the 4800 tons of material representing the launching weight had been built in seven and a-half months; in the last five months a daily average of 30 tons—on some days 60 to 80 tons—had been attained. That was an achievement with which they could be quite satisfied.

Professor Laas said he would not like to take the part of one or the other building slip system, but entirely agreed with the previous speaker that the question of which was the best arrangement could be determined only by local considerations. The small number of these plants in England was a matter worthy of remark. In the greatest shipbuilding district in the world—the Clyde—where alone Great Britain builds as many vessels as Germany, there were only two such building slip plants. The cause of this was that Germany was obliged to work with the cheapest possible means, in spite of the circumstance that wages there were comparatively low.

Dr. Ing. Foerster said that towards the close of his paper the author had pointed out the advantages of the suspension ropeway, and referred to that at the Reiherstieg yard as an example. This valuable description seemed to him to require further supplementing, for the Palmer Company's yard was very unfairly treated. A brief comparison was drawn in which the cost of the Reiherstieg plant was put down at £3500, and that of the Palmer Company at £30,000. The author should have gone on to say that the area of ground commanded by the Palmer arrangement was by about 100 per cent. the larger of the two. In another place the weights required were given, and here also the Palmer plant apparently showed an unfavourable result. The Palmer plant preceded that of the Reiherstieg in point of time, but in the latter the ability to move loads in the lateral direction was wanting, and, in his opinion, this was a highly important point. There was only one other building slip plant in which such lateral movement was not provided for, and that was in Messrs. Doxford's yard, but it was there made up for by the largeness of the number of the cranes provided; there were twenty-seven cranes to three slips, their distance apart being 9ft.; there, however, there were only two or three fixed longitudinal ropes, and the plant was very limited in its application, and insufficient. True, on the Reiherstieg system it was possible for two or three crane units to work together, but in Palmer's the working of the whole slip was more advantageous, and all the crane units could co operate at any one point. Then again the author should have mentioned that the second slip, which was included in the system, was provided with a stage work like that of Messrs. Blohm and Voss, which was highly important and a source of considerable advantage. It was by this means possible for a yard to make itself independent of the increase of breadth for a long time to come, and in case one of the slips should be unoccupied, to make use of all the cranes for a ship on the neighbouring slip. This also went to explain the excess of weight in the Palmer arrangement.

Herr Michenfelder then replied to the discussion. With reference to Herr Brinkmann's observations, he said that the high efficiency of the Wilhelmshaven locomotive tower cranes was due to the circumstance that they were not used for time-killing transport purposes, and that the conditions for a supply of material in the most favourable manner possible were there of an ideal description, so that the work was assisted in a very suitable manner. Dr. Foerster had criticised the comparison made by him between the respective costs of the Reiherstieg and Palmer Company's plants. The criticism was justified in so far as that he had not pointed out the difference between the respective areas served; but this had very little effect on the question at issue, for the principal weight of the Palmer arrangement was in the end supports. When Dr. Foerster asserted that everyone who had had to do with building slip cranes considered the want of lateral mobility a great disadvantage, he was unable to agree with him, and there were others who were of his own way of thinking. He might be right where very broad ships were in question, but not as regarded conditions like those of the Reiherstieg. For the vessels there dealt with the plant had proved completely satisfactory; otherwise the second set would not have been added. Dr. Foerster had further declared it to be a defect connected with the want of lateral mobility that the various crabs could not work together. In the Reiherstieg arrangement, however, this was perfectly possible. Then again he should like to point out that he had called particular attention to the advantages of the arrangement of two building slips together, as in the yard of Messrs. Blohm and Voss, and to those of the transverse-working trestle crane on the water front.

The last paper on the list was one on "Wage Tariff Agreements (Lohntarifvertrag) in the Shipbuilding Trade," by Dr. F. Hochstetter, of Berlin.

We may say, in explanation of this paper, that the Lohntarifvertrag is an agreement between employers' associations and trades unions that certain rates for certain classes of work shall rule for a specified number of years. Such agreements already exist in the German printing and other trades, and they have their counterpart in our sliding-scale arrangements in several trades. An agitation is on foot in Germany to make them universal and compulsory, the idea being that Parliament shall decree that work may only be carried on on such terms, but Parliament itself would not settle the rates. The Socialists have recently proposed that no Government orders for ships should be given to yards in which such agreements do not exist.

After some introductory remarks on the gradual development of the labour conditions, Dr. Hochstetter passed on to the most modern form of labour convention, the collective one, the nature and importance of which he illustrated by a comparison with the individual covenant. While showing great sympathy for tariff arrangements concluded on the basis of constitutional labour conventions, he was able to admit their advantages only for trades of the handicraft order which in general had no foreign competition to face—but not for the greater industries. He showed that the wages paid by German yards depended in the first place upon the state of the international market—that is to say, on the competition of English and Dutch rivals, who, as regarded the conditions of natural production, were more favourably situated. The whole German shipbuilding industry might be placed in jeopardy if the yard managers were bound to wage tariffs which were based on other considerations. Again, the minute specialisation and frequent alteration of the working methods and apparatus of modern shipbuilding would very soon frustrate every attempt at a tariff arrangement. To these main reasons came the unfavourable experiences with the wage tariffs established in English shipyards.

The discussion was opened by Wirklicher Geheim Admiralitätsrat Harms, who observed that the author had said that a resolution had been adopted by the majority of the parties in the Reichstag *without* objection on the part of the Government to the effect that in future the Naval Administration should place contracts only with firms that had tariff agreements with their workmen. He had underlined the word "without;" this was not quite correct. In the Budget Committee the Secretary of State had expressed his misgivings on the point, and declined to commit himself with regard to it, because this question went far beyond the limits of his department. At the plenary sitting an opportunity of repeating this declaration had not presented itself. The resolution had been adopted by the Reichstag; inquiries were being instituted, commissarial negotiations were being conducted, and as a result of these the allied Governments would have to take up a position with reference to the question and give their answer to it. Negotiations on a question of such high importance were of long duration, and he would advise the author to leave out the words, "without objection on the part of the Government" when the paper came to be printed.

Dr. Ing. Vielhaben said the author had given a picture of the tariffs without referring to the difficulties attending the question. He could not have done this in the short time at disposal, but an indication in his paper as to the burning nature of the question would have been desirable. Eminent lawyers and social economists had worked hard to place the tariff agreements on a legal basis, and he believed the attainment of this end was nearer than was generally supposed. He would not go into the paper in detail, but would make practical proposals. The author had declared against the tariff agreements; in ninety cases out of a hundred, however, piecework prices were paid. There were inferior workmen in other branches also, and foreign competition likewise existed in other trades. When the settlement of the question was close at hand resistance should not be offered. He would like, then, to propose that a settlement of the question for all the German yards be taken in hand or supported by the Schiffbautechnische Gesellschaft. This settlement would come sooner or later, and it was better that the shipbuilders should make it themselves than that they should have it forced upon them. Professional men generally were much pre-occupied with their daily work, and were apt to turn their attention to such laws only after they have been enacted. But it was then too late. They should, therefore, themselves institute inquiries, and after working the subject up in a practical way, place the results at the disposal of the Government.

Wirklicher Geheimer Baurat Wiesinger said he thoroughly agreed with the utterances of the previous speaker. It would not be long till the "powers that be" turned their attention to the wage agreement question, and it was urgently necessary, therefore, that attention should betimes be bestowed on the preparation of the groundwork for them. He was of opinion that the arrangement of a tariff was not so very difficult; for, as a matter of fact, the bases for it were everywhere in existence. In the paper it was said that the tariff agreement was to lay down how work was to be carried on and what work was to be done. The point as to how work was to be carried on was already settled, for their social laws regulated this in a high degree. What work was to be done was, in part, a more difficult question; the question of the remuneration that was to be accorded to the workmen then came in, especially for the managers of private yards; it made the standardising of the wages extremely difficult, and for the complicated operations of shipbuilding it was, in fact, altogether impossible. In every yard there was a minimum wage, and there were a whole series of piece-work rates, which were not, indeed, officially sanctioned, but which, nevertheless, were in actual existence, so that a development of the tariff question was not difficult, and material was there to work on. True, he would consider it a great mistake if the Navy-office were to follow up the suggestion of the Budget Committee and place orders with the private yards in the sense of the resolution here proposed. The result would be that both sides would suffer—the navy in so far as it would not always be so well served as the private yards, and as its freedom of action in dealing with the workmen would be curtailed. He would like to advise, therefore, if he might be allowed to do so, that the authorities should, on this question, cultivate a good stiff backbone.

Herr Rosenberger said he would not say that he was an avowed opponent of tariff agreements, but it would perhaps be going too far were they to give effect to the proposal of the author and already begin to collect material. This would be going to meet coming events a little too soon; he was somewhat in doubt also whether this was their affair, although it might be a very nice question to think about. They ought to leave the matter to other societies, such as the Shipyards' Union. He was afraid the latter would be offended at their interfering.

Dr. Hochstetter, in his reply, said he only wished to touch upon the remark make by Dr. Vielhaben, that the tariff question was not to be settled in a few words. That was true. But he had only been able to deal with the two main points—namely, first, the international character of the shipbuilding industry; and, secondly, the wage system, in which piece-work principles predominated, both of these being unfavourable to the scheme. Almost the only tariff agreements that were to be found in literature bore relation to handicraft and small-trade work. There were only a few instances of them in the industries. A recent instance was that of the brassfounders; but even here it was still an open question whether the workmen preferred the tariff agreement. The workmen in the larger industries did not want any tariff agreement; it would also be very difficult to arrange the piece-work prices. The workmen were well content with the piece-work system. With the hand-labour trades, such as the municipal building trades, the case was different.

* No. II. appeared December 11th.

NEW STEEL WORKS IN THE UNITED STATES.

No. III.*

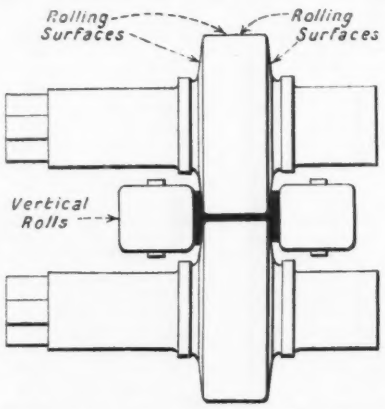
The 48in. Grey Universal Mill for joists.—We come now to one of the most important and most interesting parts of the works, namely, the plant for rolling structural shapes by the Grey process. This is operated in connection with the 46in. blooming mill, which is practically identical with the 40in. mill already described. Beyond this mill are the shear table, the 800-ton hydraulic shear, and a back table delivering to the table of the first 48in. Grey mill, which is the intermediate mill. The Grey 48in. finishing mill is 300ft. beyond. The blooming—or roughing—intermediate and finishing trains are arranged in tandem for continuous rolling from the bloom to the finished product without reheating.

The Grey mill uses separate horizontal and vertical rolls, instead of the grooved rolls of ordinary mills. The main horizontal rolls govern the thickness of the web; the vertical rolls beside the former govern the thickness of the flange. A supplementary pair of horizontal rolls beyond the main rolls govern the width of the flanges. The general arrangement is shown by Fig. 17, in which the rolling surfaces, or those delivering pressure upon the beam, are indicated. The thickness of web or of flange, and the width of flange, can be varied independently of each other, and a thinner web can be produced than by

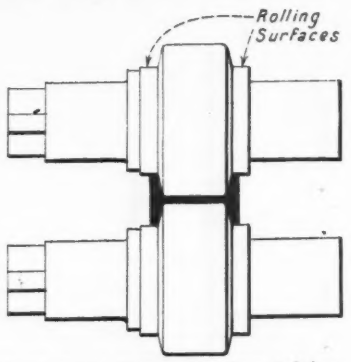
* No. II. appeared December 4th.

ordinary methods. With this arrangement, also, it is possible to produce wider and heavier flanges than can be rolled in an ordinary mill. In the latter process the web alone is formed by actual rolling; the flanges are formed by crowding and dragging the metal through the grooves in the rolls, which, of course, can exert no rolling pressure. In addition to this, the middle roll has a smaller diameter than the upper and lower rolls, so that the contact surfaces with the joist have different linear velocities. This, together with the fact that the reduction is not uniform throughout the section, results in unequal deformation and internal stress, which is indicated by varying quality of the metal in the web and flanges. The results are evident, more particularly in the larger sizes of beams. Sections produced by the Grey process have a uniform reduction in all parts by the process of rolling. They are said to show also a uniform quality of material throughout the section, due to the equality of reduction without unequal deformation, and to the consequent absence of internal stress. They are thus specially adapted for use in structures subject to vibration and impact.

A Grey mill has been in use since 1902 at the Differdingen Works in Germany, producing beams of 10in. to 30in. in depth with flanges 10in. to 12in. wide. These are used in bridge and building construction, the larger sizes being used in place of built up or riveted girders. Only one mill or train is used. At the Saucon Works, which we are now describing, there are two separate intermediate and finishing trains about 300ft. apart. These mills are larger than they are at Differdingen, and



Main Rolls: Rolling Action of Horizontal Rolls on Web & Inner Sides of Flanges; Rolling Action of Vertical Rolls on Outer Faces of Flanges.



Supplementary Rolls: Rolling Action on Edges of Flanges only. No Rolling Action on Web.

Fig. 17—ACTION OF THE GREY MILL

include a number of improvements upon the latter. They are intended specially for rolling exceptionally large joists of standard shape, and the special wide flanged or H sections, having the depth of web and width of flange practically equal. The smaller sizes of these H beams may be used as columns in buildings, thus eliminating a great amount of work now required for built up columns. The larger sizes may also take the place of riveted plate girders in many cases.

In Fig. 18 are given an elevation and a plan of one of the Grey mills. Many pieces may be finished on the intermediate train by continued passes. The two trains are desirable, however, for large sections and large output, and also to secure economy in the use of the rolls. The number of passes in each train will be determined by the section to be rolled, but the total number of passes will be from ten to fourteen; sections for beams and girders will usually be given from three to five passes in the finishing train, but one finishing pass will suffice for the heavier column sections. The blooming mill forms the beam blank, giving it an approximate H section. On reaching the intermediate train the blank passes first through the supplementary rolls and then between the main stand of horizontal and vertical rolls. The rolls are then adjusted before its return, and the process is repeated for the required number of passes. A plan of the mill is shown in Fig. 19. After the final finishing pass the beams pass over a table 240ft. long to the hot saw, which is similar to those already described. Beyond this is another table 220ft. long, which serves the hot beds. Pull-on apparatus shifts the beams from the table to the beds, where special mechanism turns them upright upon their flanges. These beds are of very substantial construction, owing to the great weight of some of the new sections to be rolled. They are of particular interest in having hollow cast iron rails, through which is circulated the discharge water from the hydraulic appliances at the beds and saws. When the beams are cool the pull-off apparatus removes them to the run-out table at the outgoing side. This delivers them to the roller straightening machine, before reaching which they are turned upon their edges in proper position for the machine. Only the narrow flanged beams require to be edge-straightened by the machine. When the mill is rolling girder or column sections, the straightening machine is shifted laterally, so that there is a continuous table from the hot bed to the storage yard for stocking or shipping. Parallel with the main table, beyond the rotary straightener, is a table serving a gag straightener.

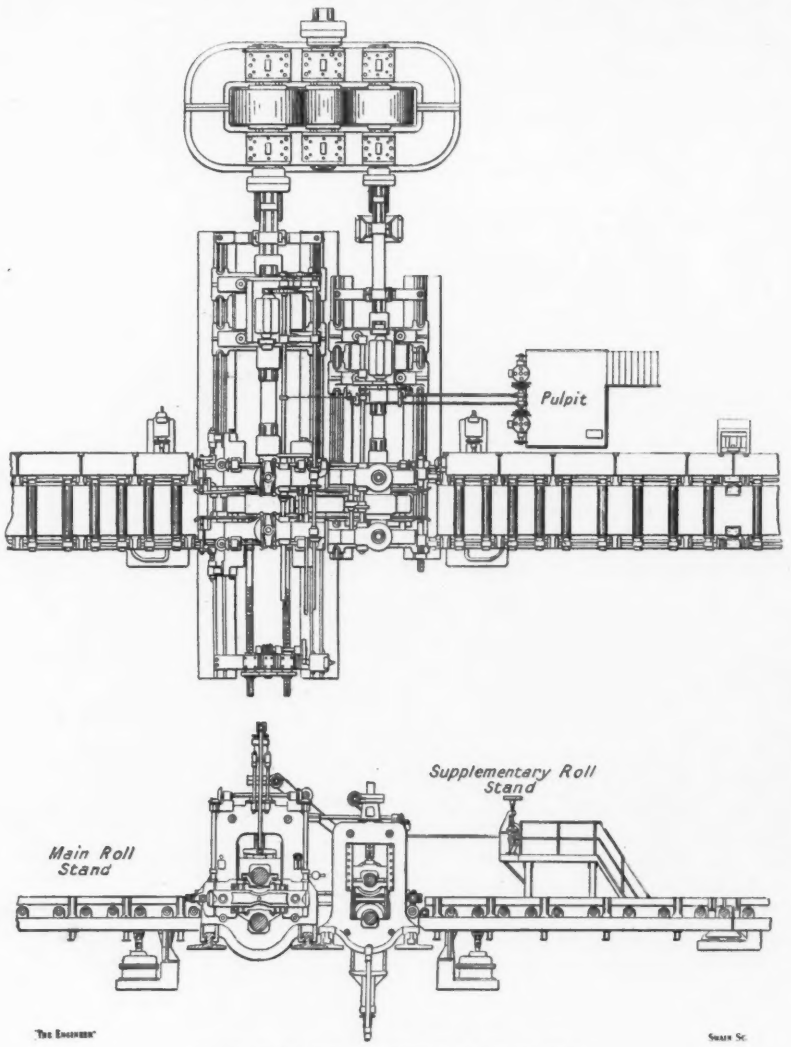


Fig. 18—PLAN AND ELEVATION OF GREY MILL

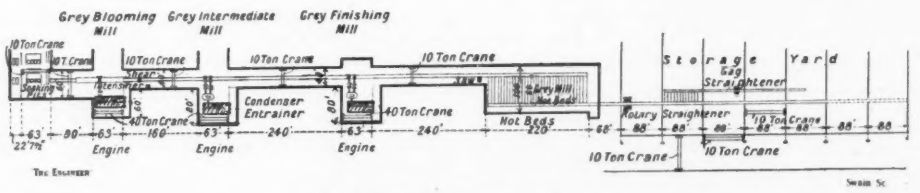


Fig. 19—ARRANGEMENT OF THE MILLS

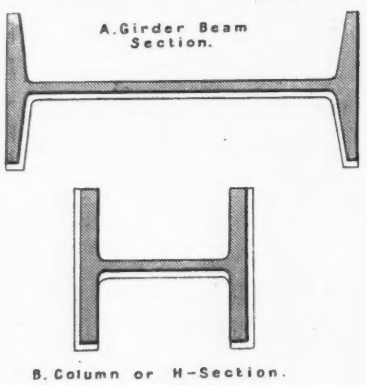


Fig. 20

Pieces requiring to be sent to the latter are shifted to its table by hydraulic transfer apparatus.

The Grey mills at the Saucon Works are intended especially for rolling the new special joists and H beam sections of the Bethlehem Steel Company. These sections, in regard both to shape and properties of strength, present advantages for building or structural work which are not obtainable with ordinary beam sections. The wide-flanged H beams can be used instead of riveted or built-up sections for a variety of purposes, with an economy in the weight of material; or with a saving in the labour and cost of punching, assembling, and riveting. In many cases there will be a saving in both material and labour. The advantages in improved quality of the metal due to the method of rolling have been noted above. In a beam section, metal in the flange is three times more effective than in the web when the moment of inertia, moment of resistance, or coefficient of transverse strength of the section are considered. By means of the improved method of rolling in the Grey mill, in which both the flanges and the web are formed by rolling operations, a more economical distribution of metal can be made between relative areas of flange and web than in the present American standard beam sections rolled in the usual way.

Wide flanged beams can be rolled which will have the same coefficient of strength as standard beams of the same depth, but which will also weigh less than the latter. This result is obtained by making the flange wider and of greater sectional area relative to the area of the web. On the other hand, wide-flanged beams of the same depth and weight as present standard sections will have a greater coefficient of strength than the latter. A beam with wide flanges can be designed and rolled which will have double the strength coefficient of an ordinary beam of the same depth, but will have less than double the weight. Such a beam could be used economically in place of a girder composed of two ordinary beams bolted together. There would be a considerable economy in weight and a saving in the expense of assemb ing, besides eliminating the bolts and spacers or separators. Larger beams can be produced by this process than by the ordinary process, and may be used to advantage in many cases where otherwise it would be necessary to use riveted girders. The

wide-flanged sections also make an economical section for columns in steel-frame buildings. Riveted columns of H section are frequently used, built up of a web plate and four angles. The rolled column has a greater radius of gyration for equal area, and with a saving in manufacture, as punching and riveting are required only for splices and connections. With the flanges made of adequate width to give sufficient radius of gyration the rolled column can be used with economy in place of other sections of riveted columns.

These special shapes will be of open-hearth steel exclusively, and owing to the methods of manufacture they have practically sharp corners. The styles of sections will be rolled:—A, special joist sections; B, girder beam sections; and C, column or H sections. In the first two the inner faces of the flanges have a slope of 1¼in. per foot. In the third the slope is only $\frac{5}{50}$in. per foot. Each depth of section will be rolled with varying thickness and weight. The increase in size of the special joists and girder beams is effected by spreading the main rolls, as at A in Fig. 20. In the H sections the increase is made by spreading both the main—horizontal—and vertical rolls, as indicated at B in Fig. 20.

A.—The special joists, from 8in. to 24in. deep, have the same section modulus or coefficient of strength as beams of the present American standard sections, but with 10 per cent. less weight than the latter. If the former is given the same weight, it has a coefficient of strength 6 per cent. greater than that of the latter. The 26in., 28in., and 30in. joists are respectively equal in strength to girders composed of two 20in. 65 lb. ordinary joists, two 20in. 80 lb. joists, and two 24in. 80 lb. joists. The sizes range from 8in. depth with 5¼in. flanges to 30in. depth with 10in. flanges; the weights are respectively 16¼ lb. and 120 lb. per foot. The web thickness is from $\frac{3}{16}$in. to $\frac{33}{64}$in.

B.—The special beam girders range from 8in. depth with 8in. flanges to 30in. depth with 12in. or 15in. flanges; the weights per foot are 32½ lb., 175 lb., and 200 lb. respectively. The web thickness is from $\frac{9}{32}$in. to $\frac{3}{8}$in. These beams up to 24in. depth have a coefficient of strength equal to that of two standard beams or joists of minimum weight of the same depth. The weight, however, is 12½ per cent. less than the combined weight of the two standard beams, independent of the weight of bolts and spacers required in building up the two beams into a girder. If these are included the saving will be about 15 to 16 per cent. The large beams, 26in., 28in., and 30in. deep may be used to advantage as girders for crane runways, bridges, and many other purposes, where otherwise riveted plate girders would be required. In floor framing of buildings, &c., the wide flanges give an increased lateral stiffness. For heavy concentrated loads or short spans with full loads the web may become the controlling factor in the strength of the beam. The sections can be increased to secure any desired thickness, and will then have greater transverse strength than standard beams of the same depth and weight.

C.—While the two previous types of sections may be used in many ways, as columns for mills or other buildings with economy in weight and labour, the special H-section was designed particularly to meet the requirements for columns in buildings. Each section is made in varying sizes and weights from the same main rolls. Thus the columns for a tall building—of twelve to sixteen storeys—can be so selected as to proper areas to suit the variations in load that the entire lot can be made at the same rolling without a change in rolls. This will result in a promptness of delivery that cannot be obtained under ordinary methods. The connections for floor girders and beams, &c., are easily made, and the lengths can be easily spliced so as to form a practically continuous column. For a two-storey length of column the shop work would require drilling or punching 91 holes and driving 13 rivets, or 100 holes and 59 rivets. A corresponding column built up of channels and plates would require some 520 holes and 240 shop rivets. In the rolled columns with thick metal the holes must be drilled. As these holes are generally arranged in groups with uniform spacing, the work can be performed economically with gang or multiple drills. In general, from 50 to 66 per cent. of the shop cost of built-up riveted columns can be saved by the use of the rolled H-column section. The sizes range from 8in. depth, with 7in. or 8in. flanges, to 16in. depth, with 15in. flanges. Taking a 12in. section with 12in. flanges as an example, the various sections—with varying thickness—range from 23 square inches to 39 square inches of area and from 78 lb. to 133 lb. per foot in weight. The 16in. by 15in. beams, with flanges $1\frac{13}{16}$in. thick, have an area of 68 square inches and a weight of 230 lb. per foot.

The Saucon Works are notable for the extensive use of electric power, and as being designed especially for the application of such power. Steam power is used to drive the rolling mills, and hydraulic power to operate the shears and other machinery requiring heavy pressure. Electric power is used for a variety of purposes; electric motors operate the reversing and transfer tables of the roll trains, the screw-down gears, saws, straightening presses, pull-on and pull-off mechanism at the hot beds, &c. Besides this the electric power is used also for the numerous overhead travelling cranes, and for the machine tools in the finishing shops for rails and structural material.

The electric motors hitherto used for operating the tables of rolling mills have been of the railway type. These, however, were designed for operating on 550-volt current, and their commutators were too small to take care of 230-volt current. In railway service, also, there are springs which relieve the motors from shocks, and in rolling-mill service the shafts are not strong enough to stand shocks unrelieved by springs. Motors operating the tables have to reverse ten or twelve times in a minute. The operation of the screw-downs is also severe work.

The electrical equipment of the Saucon Works was designed by the Crocker-Wheeler Electric Company, of Ampere, and motors of a special type were designed for the service. They include the following special features:—(1) Special arrangements to efficiently handle the 230-volt current; (2) the commutation is such that sudden reversals, and sudden and extreme overload, will not injure the commutator or produce heating; (3) the insulation will not deteriorate under the effects of heat; (4) shunt-field winding is used in addition to series field winding in order to prevent racing; (5) the starting torque is very high; (6) the parts are of ample strength, and the casing is so arranged that the parts can be inspected or renewed very easily in case of injury to the shaft or armature; (7) the armature is of comparatively small diameter to avoid danger from high speeds and to minimise the inertia; this facilitates sudden starting, stopping, and reversal. They are all fitted with solenoid controllers.

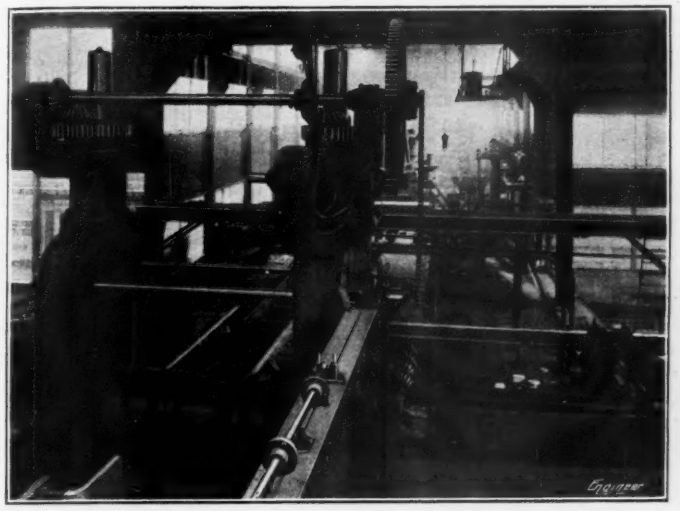


Fig. 21—SCREW-DOWN GEAR OF 46in. BLOOMING MILL

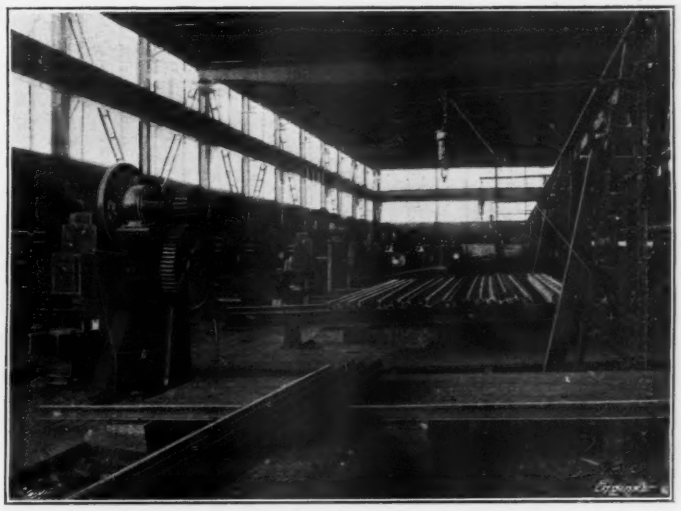


Fig. 22—RAIL STRAIGHTENING MACHINES

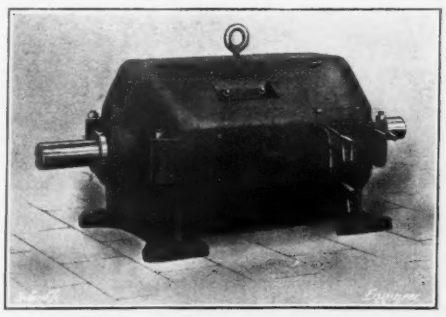


Fig. 23—50-H.P. MOTOR

There are about 120 of these rolling-mill type motors, ranging from 10 horse-power to 150 horse-power, and aggregating 6000 horse-power. These are all in the 28in. rail mill and the 46in. Grey universal beam mill. They are used for the screw-downs, reversing tables, transfer tables, cooling beds, punches, and shearing machines. There are also about twenty motors of standard types for operating the saws, straightening presses, &c. Some of the motor equipments have been shown in previous views of the works—Figs. 11, 12, and 13. In Fig. 21 is shown a 75 horse-power motor operating the screw-downs of the 46in. blooming mill of the Grey universal beam mill. Each of the Grey roll trains has also two motors of the same type for its screw-downs. Fig. 24 shows a group of fourteen motors of 50 horse-power driving the pull-on, rake-off, and transfer tables of the hot beds of the Grey mill. Fig. 25 shows the 54in. hot saw at the delivery end of the Grey mill. This is of the sliding-frame type, and is operated by a motor of 225 horse-power. The same view shows also one of the motors driving the transfer tables of the saw run. The rail mill has five hot saws of the drop type, each driven by a 45 horse-power motor; it has also a 54in. motor-driven hot saw of the sliding-frame type for use when the mill is rolling shapes instead of rails. Fig. 24 is a view in the rail-finishing shop, and shows the motor-driven rail straightening presses. These motors are of 10 horse-power.

The motors of standard types in the 28in. shape mill are equipped with Wheeling induction couplings. These render it unnecessary to reverse or stop the motor, as speed regulation is obtained by electrical control of the magnetic coupling. The shaft has a coupling at each end, and the pinion is mounted at the middle of the countershaft.

A general view of one of the 50 horse-power motors of the rolling-mill type is shown in Fig. 23. It is for 220 volts, and runs at 500 revolutions per minute. These motors are built in sizes of 7½ horse-power to 200 horse-power, and for 230 volts only. It will be of interest to give some particulars of the construction of these motors. The service in this class of work is, of course, very severe, owing to the shocks and jars, sudden and frequent reversals, and sudden heavy overload. These conditions necessitate careful electrical design to prevent sparking, heavy mechanical parts, ability to stand high temperatures, and thorough protection combined with ready accessibility. The commutation is sparkless through a very wide ranges of load, and is equally efficient in whichever direction the motor is running. The insulation is of fireproof material of ample structural strength. The bearings are proof against the entrance of dust and the escape of oil, and this is effected without the use of washers or wipers.

The frame is of steel, octagonal in shape; the upper part is removable, and the lower part has four broad feet for the holding-down bolts. It has a large hand-hole at each brush holder, and there are large openings at the rear end. All openings are fitted with dust-proof covers and rain deflectors. The removal of the upper half exposes the field windings and brush holders, and permits the removal of the armature. The pole shoes are built up of sheet steel laminations. The motors are wound either series or series-shunt. In the latter case the shunt winding is sufficient to prevent the motor running at more than twice the normal speed if the load is entirely removed.

The laminations forming the armature core are well bound together. They extend to the shaft, to which they are secured by a large key. There is no intermediate spider. The windings are simple and substantial. The conductors are made of flat strip copper without joints. The conductors lying in one slot are bound together with insulation, and the slot also armoured with insulation before the fully insulated coil is inserted. The coils are set below the surface of the coil, and are held by non-shrinkable, non-combustible wedges. They are fully secured without the use of wires or bands. The commutator bars are of hard-drawn copper with solid tails. They are thoroughly insulated from each other and from their clamping rings, and are mounted on a sleeve projection of the armature core end flange. The brushes slide in machined ways in cast boxes, and are held against the commutator by curved fingers under the pressure of coiled springs. The boxes can be adjusted to take up wear of the commutator. All connections to the brushes are made outside of the frame.

The armature shaft is of forged steel of large diameter, and can be removed and replaced without disconnecting the armature leads. It is of such length that a pinion can be attached at one end and a brake at the other end. The sealed bearings are cast iron split cylinders lined with Babbitt metal. Any flow of oil along the shaft is stopped and returned to the reservoir by a groove or gutter

surrounding the shaft near each end of the bearing and by the overhanging apron, which is a part of the casting. The pinions are of forged steel, and the gears are of cast steel with teeth cut from the solid. The teeth have wide faces, so as to stand up under the heavy and jerky load. The countershafts are exceptionally large. The gear case is of cast iron divided horizontally, and having self-closing covers for lubricating the gears.

THE OUTLOOK IN THE TRANSVAAL.

Johannesburg, November 16th.

During the past six months the position in the mining industry has taken a distinct change for the better. The continued reduction in mining costs has made it feasible for properties, which a year ago were not considered payable, to commence operations, and the addition of new producers will be steadily maintained.

The four latest producers are the Simmer Deep, the Cinderella Deep, the Aurora West United, and the West Rand Mines. To these will shortly be added the Knights Central and the Geduld; and in a short while the Bantjes will also be included in the producing mines.

The Simmer Deep, with its 300-stamp mill and a full equipment of tube mills, will be an important factor in the gold output. It is the best example of up-to-date mine equipment, and, when it has been in full work for a few months, its costs should be as low as those of any of the Deep Level propositions.

The Cinderella Deep has started with fifty stamps, but it is believed that the equipment will be very shortly increased. Both this mine and the Simmer Deep have arranged the batteries to be driven by electric motors, current being supplied for the purpose from the Victoria Falls Power Company's plant at Brakpan. The two mills are driven in units of twenty stamps and ten stamps respectively, by motors driving through short countershafts for the necessary reduction of speed. The Cinderella Deep system of twenty stamps on one motor will, however, hardly be followed in the future; it is realised that if the full benefits of electrical driving are to be obtained, it is essential that the units be cut down to the lowest possible number of stamps. This is due to the fact that the stoppage of a motor for any purpose, and necessitating the stoppage of the whole of the stamps driven by it, is a more important item than the slight increase of efficiency, and the corresponding decrease of running costs, in the economics of reduction operations.

The West Rand Mines plant of eighty stamps is to be at once increased by a further twenty stamps. The existing mill consists of the old battery of the Violet Mine Company, which was some years ago amalgamated with the West Rand Mines, reconstructed and re-erected in a more suitable position than it originally occupied. An equipment of tube mills has been added. The additional twenty stamps will be driven electrically in units of ten.

The Bantjes Mine has been dewatered, and the erection of a battery is to be put in hand at once; it is anticipated that the battery will be crushing within nine or ten months.

The Knights Central Mill is well under way, and a few months should see it amongst the producing mines.

The Brakpan Mines, which have, by their excellent development results, given an extra fillip to the far eastern section of the Rand, are to be equipped at the earliest possible moment, the design of the plant having been taken in hand by the mechanical engineering department of Messrs. Neumann. Early developments are anticipated both at Randfontein and East Rand, and orders for machinery for both these groups should be issued at an early date.

In the meantime the outside districts have had the attention of the individual miner. There has been considerable activity in several districts, and batteries of from five to twenty stamps have been erected on many properties by small parties of men who are working either entirely on their own behalf or else for small private syndicates. The success which has been met with by these men has proved most encouraging, and numerous parties are starting out with the same aims. This departure from the old policy of pegging out claims and then sitting on them with the hope of selling out to the "big houses" will prove a most useful factor in opening out the back country. The equipment of these properties is done on most economic lines, second-hand machinery being for the greater part installed. This policy has pretty well swept the mines clear of the suitable second-hand plant, and there is a considerable demand for small light stamps. Several steam stamps are being experimented with, and it is well worth the while of those interested in these designs to appoint agents in the Transvaal, as this type of plant will be most suitable for outside districts. Many of the small propositions have been fitted with suction gas plants, which are fired with charcoal; this system is most advantageous in the districts where there is a supply of timber which is limited, and where natives can be obtained to burn the charcoal at piecework rates.

The cost of running a gas engine of 15 horse-power, driving five 750 lb. stamps, has been brought as low as 3d. per hour, or one-fifth of a penny per horse-power hour, under favourable conditions as to timber and native labour. This in districts where the cost of firing boilers with timber would be prohibitive.

Considerable interest is being aroused locally by the preparations being made by the rock drill contest, which starts early next year. Many of the drills have arrived, and are undergoing preliminary trials at the hands of their representatives. Local inventors are making earnest efforts to perfect their drills, and the awards should go to those machines which are either locally designed or which have been experimented with locally in order to adapt them to local conditions. Those manufacturers who have not studied local conditions in their designs will hardly show up creditably in the tests, for there is little doubt that rock drilling machines have most severe conditions to work under on these fields.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

As briefly indicated in the account given in our last impression of the new buildings of the Institution of Engineers and Shipbuilders in Scotland and its ceremonial opening, the first regular meeting of the session was held on the 8th inst., five days after the members had been welcomed to and entertained in their new home at Elmbank-street, Glasgow. Mr. John Ward delivered his presidential address before a gathering which almost entirely filled the large lecture hall of the Institution, seated for about 500. The address, which was one of great length and comprehensiveness of view, dealt chiefly with the effects of the progress of engineering on the social advancement of the people, and traced the complex effects of the development of productivity in industry due to mechanical over manual methods of labour. The proved economy of the steam engine consequent on the application of the compound system brought a revolution. A great social change was effected by the creation of large factories, which superseded home industries. In that and in all successful commercial operations the aim of the industrial economist was to increase the productivity of labour, and labour was used in the broadest sense, embracing all effort, whether muscular, mental, or artistic. The late Lord Playfair instanced that machine methods increased production of metals and metallic goods by 33 per cent., and machinery by 40 per cent.; while another noted economist estimated that in this country in the thirty-five years following the general adoption of steam machinery—between 1850 and 1885—the rise in productiveness was equal to 40 per cent. The immediate effect of the change from manual to mechanical methods was disastrous to labour, but the ultimate application of steam to ocean and land transport saved the situation created by the social revolution which followed the extension of the mechanical factory system. It was found, for instance, that the workmen in a factory could in a given time make thirty times as many ploughs as the same number of handworkers in the earlier days. A market for a greatly increased number of ploughs was required. The steamship found it in foreign lands, and the grain which was produced with the help of these ploughs could become the commodity exchanged for them. Commerce had attained to much more complicated schemes of exchange, but this simple example told the story. The widening of the market had been the work of the shipbuilder. In their yards the amount of work done by mechanical means was at least five times greater than that formerly possible with hand labour of a given capacity. The cost of a cargo steamer per ton carried was less than two-thirds of the price thirty years ago. Great economy, too, had been attained in the working of ships; steam steering and cargo gear and other appliances—and the disuse of yards and sails—had reduced the manual labour 60 per cent., as compared with the "sixties" and "seventies." The improved efficiency of propelling machinery had even greater effect in reducing the cost of ocean transport. One ton of cargo was carried for 100 miles for 4 lb. of coal in large capacity 12 knot ships, whereas thirty or forty years ago it was many times that cost. While we had gained immensely in the greater extent of our markets, we had also profited by the wider ranges of our sources of supply. We took our iron ore from Spain, Norway, or Sweden; our copper from Spain; our nickel from New Caledonia and Canada; our cotton from America; our wool from South America, the Cape, and Australasia; and our timber and other supplies from nearly every country. A question now forcing itself to the front had reference to the extent to which the raw material was to be prepared at the source of supply. The answer depended largely on financial considerations. National wealth was the outcome of manufactures rather than of natural supplies, and a higher opulence was assured where the material won from Nature was made into finished products than where it was exported in its raw state. That being so, they must anticipate developments in the direction of a greater measure of work carried out at the source of the supply of their material. Competition must become keener in this respect, especially where the manufactured or partly manufactured articles were lighter and less bulky, or more convenient for transport, than the constituent raw materials. Such competition could only be met by higher efficiency of labour, which resolved itself largely into a question of greater productivity, improved machinery, and therefore of the utilisation of more capital.

Sir John Wolfe Barry, the Chairman of the Engineering Standards Committee, addressed the members of the Institution on "Standardisation and its Relation to Trade," in their new home on December 11th, the chair being occupied by Mr. John Ward, President of the Institution. It was almost unnecessary, the lecturer said, at the present time to insist upon standardisation as an aid to economic production. In 1901, when he suggested to the Council of the Institution of Civil Engineers that some definite action should be taken by them to draft suitable standard forms for iron and steel sections, the fear was expressed that it would tend to discourage individuality of design, and that there might be a tendency towards a stereotyping of forms, which ought to be varied to meet requirements as they arose. On the other hand, it was pointed out, first, that the system proposed was not of a nature that could affect the design of the assembled parts in a bridge, roof, or ship in which the individual mind would have as full play as ever; and, secondly, that the idea proposed was not the adoption of standard forms once for all, but that a cardinal point was that some committee of qualified persons should be instituted, who, after dealing with the subject at that particular epoch, should have a continued existence in order to discuss, and, if approved, adopt additional standards forms which from time to time were shown to be proper and desirable. It was demonstrated that the results of the want of system in the case of rolled sections of iron and steel were, first, unnecessary cost of the article due to the cost of the rolls and the constant changing of them for different orders; secondly, delay in production while special rolls were being made and changed; thirdly, the impossibility of manufacturers stocking at slack times any large quantities of any section because they could not manufacture with prudence rolled sections which might not be required for years.

Proceeding, the lecturer recounted the steps by which, eventually, a large and influential committee was formed, through the co-operation of sister institutions, and the Standards Committee established. He pointed out that it soon became apparent that the engineering industry of this country would profit considerably in many directions if standardisation on a judicious scale were initiated in the nature of the materials as well as in the form of the manufactured articles. Diversity of specifications was placing our manufacturers at a disadvantage when competing with foreign firms. Cases were not wanting in which purchasers, though insisting upon rigid specifications when contracts were given to firms in this country, were willing to accept less rigid conditions when placing their contracts abroad. Foreign manufacturers were often in a position to put forward as alternatives specifications and tests largely adopted in their own country, and were thus enabled to tender at a lower figure than British firms, who had not acknowledged standards to put forward, but had to work to the divergent views of different purchasers. While a good deal had of late been done in other countries in the way of standardisation by various bodies, in no country had the work been so systematically organised as here, where, in addition to the main committee they had now sectional committees dealing with particular branches, the work of each being co-ordinated and unified by the former. There were now thirty-nine committees at work, comprising nearly three hundred members.

Coming to speak of shipbuilding and marine engineering, a series of standard sections and specifications for materials used had been drafted by the sectional committee having to do with that branch, which were of striking value. The results of their labours had been adopted by Lloyd's, and the other registry societies, as well as by the Government. That such unification amongst the leading Government departments and ship registry societies must be of commercial advantage to both steel manufacturers and shipbuilders could not be denied, and it must be evident also to shipbuilders that, if promptness of delivery was to be attained, the more closely they adhered to the standard sizes the more the steelmakers would be put in a position to give them prompt delivery. Among other instances in which the commercial advantage of standardisation was equally obvious were those of rolled sections for buildings and bridge work, tramway rails, locomotive building, and Portland cement. The electrical industry also was likely to benefit by standardisation, for the committees were endeavouring to throw as much light as possible on the intricate subject of insulating materials—the weak side, as it were, of all electrical machines. Experiments were now in process the results of which should be the means of bringing into line the present divergent opinions as to the question of fatigue in those insulating materials upon which so much of the satisfactory working of electrical machinery depended. One of the most frequently advanced criticisms of the principle of standardisation was the risk of impeding progress through the stereotyping of design, but the main Committee had taken means to secure that an opportunity would be given from time to time for the consideration of each type of drawing and specification, so that they might not become hide-bound, but be ready to deal with all improvements. The main Committee had been fully alive to the disadvantages which might make themselves apparent, due to injudicious standardisation, but he did not think that harm could result, seeing that the Committee charged with the preparation of the standards was composed of men representative of engineers, users, and manufacturers who were actually engaged in their daily practice with the subjects in which they were dealing.

The commercial and technical sides of engineering were inseparably linked together, and whatever the perfection of mechanical methods in production might be in this country, unless the commercial side of the business was equally efficiently organised there would be no adequate return. There were many markets which in days gone by were exclusively British, but in which we no longer held supremacy, because, by quickness and despatch, and not through the superior quality of their material or excellence of workmanship, Germany and America had been able to beat us. Of course, there were markets in which we could not hope to compete successfully on equal terms by reason of imposts and protective duties, but the work which had been effected by the Committee should very materially assist us in keeping the trade of our Colonial Empire in the hands of British manufacturers.

THE RECIPROCATING MARINE ENGINE.

Although Manchester has for some years been able to pride itself on its importance as a seaport, marine engineering has not yet become a local industry of corresponding magnitude. This, no doubt, accounts for the scarcity of papers dealing with marine practice which have been read before the Manchester Association of Engineers. On Saturday last, however, Mr. D. Gibson, of Horwich, read a paper on the "Reciprocating Engine in Marine Practice, and its Probable Future," before this Society, and, judging from the large audience, and the number of members who took part in the discussion, there is a very lively interest taken in marine propulsion

MACHINERY AT THE SAUCON WORKS

(For description see page 635)

Fig. 24—MOTORS OPERATING THE PULL-ON, PULL-OFF, AND TRANSFER TABLE

Fig. 25—54-INCH HOT SAW OF THE GREY MILL

by the local engineers. The paper had the merit of being thoroughly practical. It was intended to review the types of marine reciprocating engines now prevailing, and to note the considerations that usually determine the adoption of each type. The author dealt first with the triple-expansion three-crank engine. This type of engine is not often adopted for higher powers than 4000 indicated horse-power per set, and the largest sets now running are in the American liner New York, and the White Star liners Teutonic and Majestic, the cylinder sizes and powers being :—

	H.P.	I.P.	L.P.	Stroke.	I.H.P.	No of sets.
	in.	in.	in.	in.		
New York..	45	71	113	60	9200	2
Teutonic and Majestic ..	43	68	110	60	8500	2

About 70 per cent. of the world's commerce is carried on by ships fitted with three-crank triple engines, and having single or twin screws, according to the power required. The speeds of these vessels vary from 8 to 14 knots per hour, but the most of them are below 12 knots. For a 12-knot speed the power required will seldom exceed 4000, even for very large vessels, and for this power and upwards twin-screw engines are generally adopted.

Where the power required per propeller is 4000 indicated horse-power and upwards, particularly in vessels making long trips, quadruple-expansion four-crank engines with boiler pressures of 210 lb. to 220 lb. are finding increased favour. The extra weight of engines and boilers due to the higher pressures and ratio of expansion is to some extent compensated by the saving in fuel carried and consumed. The largest ocean liners, such as the Cunard twin screw steamer Caronia, sister to the turbine steamer Carmania, and the huge vessels of the White Star Line, namely, the Baltic, Cedric, Celtic, and Adriatic, are equipped with twin screw four-crank quadruple-expansion engines. Compared with three-crank triple-expansion engines of 180 lb. working pressure, the weight of the four-crank quadruple engine per indicated horse-power, including boilers and their water, is 8 to10 per cent. heavier with the same revolutions, although the boiler proportions may be 5 per cent. less. The saving in fuel averages from 6 to 7 per cent. in favour of quadruples. On the other hand, however, the author points out that the additional engine with extra cost of repairs and maintenance due to the higher pressure make an inroad upon the fuel saving, especially in low-powered ships. A compensating advantage in the case of high-powered Transatlantic passenger ships is the absence of vibration. The author illustrated a set of quadruple four-crank engines balanced on the Yarrow, Schlick, and Tweedy system.

The next part of the paper dealt with triple-expansion four-crank engines. The four-crank triple with the high-pressure and intermediate-pressure cylinders in the middle and a low-pressure cylinder at each end, balanced on the Yarrow, Schlick, and Tweedy system—in the same manner as a quadruple—has been introduced with marked success in lieu of the three-crank engine. Most cross-Channel steamers and warships are now fitted with this type. Quadruple-expansion engines are sometimes fitted instead of triples, but where the conditions of speed and weight allowed are severe, as in this type of vessel, the extra 8 to 10 per cent. of weight of boilers and machinery over triple-expansion is inadmissible, notwithstanding the superiority of the quadruple in fuel economy. Another objection the author pointed out to the quadruple engine in fast Channel steamers is the falling off in economy that takes place when the steam pressure is not rigorously maintained at the designed figure.

On the subject of steam-jacketing, Mr. Gibson said that this has no recognised part nor advantage in current marine practice. The conflicting nature of the reported results and the small range of temperature in each cylinder have had the effect of eliminating it from commercial consideration. It was pointed out, however, that the use of steam jackets on warship engines has a peculiar value on account of the full power being seldom required, and the necessity of making long voyages at perhaps one-sixth of the total power, in which case the low-pressure cylinders are doing little or no work, and are virtually acting as condensers. With regard to superheating, the author said the current view of the practical engineer is that with boilers of ample capacity for their work, the quality of the steam is sufficiently dry to give a net economic result that can seldom be surpassed by superheating. The great weight of superheaters is perhaps the chief objection. The marine engineer does not strain after a high degree of superheat. If he can get reasonably dry steam he is satisfied. It is often stated that any superheat less than 100 deg. Fah. does not pay; but the probability is, that if the weight of superheaters could be afforded, a superheat of 100 deg. Fah., or even less, if the plant were installed in a large fleet of steamers, would in the aggregate show a reasonable saving on the outlay. There are several steamship owners now adopting superheating extensively. Net results are carefully guarded; but the continuance of the practice where tried indicates that it is satisfactory. The amount of superheat is about 150 deg. Fah., and the saving in fuel varies from 12 to 15 per cent. In some steamers where there is a good deal of priming, the saving runs up very considerably, sometimes as high as 25 to 30 per cent. In many cases the coal per indicated horse-power is as low as 1.2 lb.

Mr. Gibson concluded his paper with a forecast of the probable future of the reciprocating engine. For fast cross-Channel steamers and fast Atlantic liners, from 18 knots up to the highest speed, he said everything at the present time points to the conclusion that the steam turbine has come to stay, especially for the highest speeds. The enormous increase in horse-power required for a small increment of speed—which exceeds the cube and sometimes the fourth power of the speed—alters all factors greatly. The lines of the ship become extravagantly fine, necessitating the smallest possible displacement for the length of vessel. These factors, together with speed, permit of the economical adoption of smaller diameter propellers and high rates of rotation suitable for turbines. The size and form of turbine give scope for the distribution of power into three or four propeller shafts, thus allowing a wider choice in the size of propeller and turbine unit to give the best results. The saving in machinery weights, including boilers, is about 20 per cent. in favour of the turbine, and the fuel consumption is about the same as the triple-expansion four-crank engine in cross-Channel steamers.

With regard to very large freight carriers of the intermediate type of liners, with speeds from 12 to 18 knots, and power varying from 4000 to 10,000 indicated horse-power and upwards, the combination of reciprocating engines with turbines gives promise of being generally used. The author mentioned the White Star liner Laurentic and the New Zealand Shipping Company's steamer Otaki as examples. For tramps and moderate-sized freight ships of 8 to 12 knots speed, where the power will not exceed, say, 3000 indicated horse-power, the author believes that the greater portion will continue to be fitted with the three-crank triple-expansion engine and the remainder with the quadruple-expansion engine.

The reading of the paper was followed by a discussion in which Messrs. Neilson, Pearce, Ingham, Winder, Roy, Anderson, A. Saxon, Gass, Lee, and Mr. Hughes, the president, took part. Mr. Neilson mentioned a disadvantage of a mixed system of turbine and reciprocating engines in the difficulty of obtaining a sufficiently good vacuum. He said that in the Otaki the vessel has a larger displacement than the sister ship, which meant increased engine power and cost. He advocated the turbo-electric system of propulsion on account of lightness, efficiency, economy, and manœuvring power. Mr. S. L. Pearce saw no difficulties in the application of the turbo-electric drive. He alluded to the balancing of a four-crank triple-expansion engine built by the Wallsend Slipway and Engineering Company for the Stuart-street power station of the Manchester Corporation in which the sequence of the cranks is as follows :—First, high-pressure; second, first low-pressure; third, second low-pressure; and fourth, intermediate-pressure crank. The engine has steam jackets, which are found advantageous chiefly for warming up before starting. Mr. Ingham alluded to the first quadruple engine which was built by Daniel Adamson for driving a mill at Hyde. It proved a failure on account of the impossibility of obtaining steam at sufficiently high pressure. Mr. Ingham saw an advantage in the construction of marine engines so that the intermediate cylinders could be cut out and used as condensing cylinders at low powers. Mr. Winder disparaged the turbo-electric system of driving steamships, and said that superheating ought to be adopted with reciprocating engines, owing to the large clearances. Mr. Anderson mentioned the possible difficulty of obtaining a sufficiently good vacuum with low-pressure turbines when in Indian waters, and the corresponding inefficiency. Mr. Gass advocated the radial valve gear in preference to the Stephenson gear on account of its lightness, and Mr. Lee mentioned what the effect of the Gulf Stream water at 80 deg. might be on the vacuum in the condenser of the turbine. Mr. Hughes remarked on the tremendous increase of power required to obtain a comparatively slight increase of speed after a certain point had been reached.

A vote of thanks, proposed to Mr. Gibson by the President, Mr. Hughes, concluded the proceedings.

THE FIRST FRUITS OF THE PATENTS ACT, 1907.

We have not had to wait long for an opportunity of learning the fate of those who presume to ignore the recent change in English patent law, for on December 9th the Comptroller-General, for reasons which he states in a carefully reasoned judgment,* revoked two patents of which a Belgian company is the exclusive licensee for England. Inasmuch as the Comptroller has enunciated certain principles of general application, it may be useful to refer briefly to the facts of the case. It appears that the inventions in question, for which patents were taken out in 1900, were for the manufacture of imitation stone slabs or tiles by an admixture of a fibrous material—like asbestos—with cement. In January, 1906, the Société Anonyme Eternit became the exclusive licensee of the patents for England. This company erected a factory in Belgium, and imported largely into England, but has never manufactured in this country. In these circumstances Mr. Charles William Zerenner applied to the Comptroller under Section 27 of the Patents and Designs Act, 1907, for the revocation of patents on the ground that the process was carried on exclusively outside the United Kingdom. The grounds of the application were that the supply of the patented goods to the United Kingdom depended upon there being a surplus on the Continent, and that, if the fact were relevant, the company could not meet the demand in this country. It was also pointed out that no steps were taken to set about manufacture in this country until July, 1908, when a few advertisements were published, and that persons desiring to use the process in England could not do so, but were subjected to harassing litigation. On behalf of the company it was urged that its existing factory in Belgium was capable of supplying the English market, and that it had advertised for firms who would become licensees. It was also urged on behalf of the company that it should be treated with leniency, inasmuch as the patents in question had been taken out before the Act of 1907 was passed.

In giving his decision, the Comptroller came to the conclusion that the patentee had been inactive in this country, and did not show reasonable cause to explain that inaction. He said: "It is obvious that in determining this question, regard must be had not only to the interests of the patentee, but also to those of the public; and that the mere fact that it would be more profitable or convenient to a patentee to manufacture abroad, than in this country, cannot be regarded as a satisfactory reason for not taking the necessary steps for introducing the manufacture into this country." Dealing with the question of advertisements and offers to sell the patent rights, he came to the conclusion that the fact that no answers were received by the patentees was not a satisfactory reason for not manufacturing in this country. The advertisements had been inserted late in the "year of grace." He also drew attention to the important point that a person buying a patent which is not properly worked in England takes it with all the faults attaching to it owing to its not being worked. With regard to the suggestion that persons who had taken out their patents before the passing of the Act should be treated with greater leniency, it was necessary to observe that the Act of 1907 had also conferred a number of substantial benefits on patentees. Moreover, every patentee had been notified of the change in the law. To have treated the patentees in the present case more leniently would have been to extend the year of grace. The Comptroller also dealt with another suggestion, namely, that the application should be refused because the applicant had no intention of manufacturing the patented article himself, his only object being to obtain liberty to import from France or Germany. He said: "Suggestions of this kind, whether well grounded or not, are irrelevant. I have often heard it suggested that the section is unduly hard on patentees, because it enables any person to apply for revocation even though he, in doing so, may be a mere busybody concerning himself in a matter in which he has no personal interest whatever. This is the first time I have heard it suggested that an applicant is disentitled to obtain an order for revocation because he is personally interested in the revocation."

One further point remains to be noticed. It had been urged, on the part of the patentees, that, as the result of the application would not necessarily be to establish a new industry in England, the patent should not be revoked. The Comptroller expressed the view that, even assuming revocation did not bring about the erection of factories in England, it would have the effect of allowing free importation from France and Germany, which might, in itself, be beneficial to the public as conducing to a lowering of the price. He said: "I have always regarded the object of the section as being to put a check on the practice which was alleged to prevail very extensively, taking out and maintaining patents in this country, not with any intention of working them here, but with the object of preventing the patented articles from being manufactured here, and from being imported by any other parties than the patentees." In the event the Comptroller made an order revoking the patents forthwith. He granted the applicants 45 guineas to cover their costs.

The moral of this decision is plain. A patentee must either work his patent in England or run the risk of having it revoked. Every defence which could have been urged appears to have been raised in the case before us, yet without avail. Amongst the points to which this decision of the Comptroller directs attention there are two of particular importance. In the first place, the applicant need have no interest, or, what is more important, he may even have a sinister interest in procuring a revocation. In the second place, the Comptroller takes the view that the applicant need not show that the patented article will be manufactured in this country. Whether this view will be maintained in a higher Court remains to be seen, but it is reasonably plain that if the new Act is to be interpreted in accordance with this decision of the Comptroller it will not be a dead letter.

* A copy of the judgment can be procured at the Patent-office for 1s.

THE TRUE PRINCIPLES OF MECHANICS.*

By Sidney A. Reeve.

For over two centuries—indeed, ever since the inception of the science of mechanics—Newton's laws of motion have been its accepted foundation. These laws may be listed, for the purposes of the present review, in the following form :—

I. Each two portions of mass in the universe attract each other with a force which is proportional directly to the product of their masses, and inversely as the square of the distance between them.

II. Action is equal to reaction.

III. Motion between two mass-portions, once existent, persists in a straight line indefinitely, except as it may be altered by the presence of a deflecting, accelerating, or retarding force.

During these two centuries of its growth the science has been used almost exclusively in application to three problems only, viz. :—

(1) The tracing of the orbits and forces of the solar system.

(2) The study of the trajectories of projectiles in their temporary orbits near the surface of the earth.

(3) The forces involved in the constrained motions of mechanical bodies, such as pendulums, fly-wheels, railroad trains, &c., which are guided in prescribed paths by a more or less solid attachment to the earth.

Each of these applications constitutes a distinctly special case. The first is special in that one of the two masses involved in each pair is overwhelmingly greater than the other. This has led to the assumption that this larger mass, that of the sun, was a constant which must enter all equations; and thence to a tacit agreement to drop it out of recognition as one of the variables at all. This erroneous assumption is not only universal in our school text-books, but it appears early in the pages of "Le Mécanique Céleste" itself.

The second application is special in the same way, and

* See The Engineer, October 25th, 1907.

also in that the orbit is only temporary, its freedom being soon interrupted by collision with the earth.

The third application is special in that the bodies are never free at all, but move in paths constrained by forces transmitted through solids and liquids.

The science has thus grown up in a specialised form, trained by artificial guidance into particular paths; and its concepts, as commonly taught, have become perverted into these special distortions.

Moreover, the last two centuries have also witnessed the phenomenal development of other sciences. Chiefly relevant to our thesis are the sciences of chemistry, thermodynamics, and electricity. Each of these sciences is primarily a study of energy. While chemistry has been delving chiefly in the intricacies of organic compounds, while thermodynamics has been concentrating, perhaps too closely, on the mathematics of the perfect gas, and while electricity has been over busy in collecting a notation and a proper store of physical data, yet the general theories of all have been tending toward a foundation of all their concepts and principles more and more clearly upon the fundamental concept of transmutable energy. Astronomy, too, has been experiencing the same process, in undergoing its sublimation from astrokinetics into astrophysics. Biology has turned its face from anatomy and histology toward problems of energetic equilibrium. Even in the apparently special field of sociology the science is now being revamped into a foundation upon the concept of social energy, rather than upon the obsolescent idea of the purely geometric action of the human individual, under assumed special forces or conditions.

Meanwhile, the power-house has grown up among us, the automobile and power boat have arrived, electrical phenomena are ultra familiar, and the minds of even the multitude have been familiarised with energy transformations upon every hand.

In each of these fields of thought the concept of energy is of fundamental importance to the student. In each it has become of increasing importance that the assumption of special conditions should be eliminated, and generalities sought instead. Between each two the occurrence of energy transformations increasingly bridges and blurs the gap which demarks their heterogenity; chemistry is now half thermodynamics and half electricity; electricity now no longer distinguishes itself from light and many other things; while thermodynamics, concerning itself with the "waste heap of the universe," draws sustenance from all. And in each the tendency is increasingly to refer all concepts to the simple and more familiar ones of mechanical mass, motion, and force.

In the light of changes so permeative as these it is not too much to say that mechanical concepts based, as now, upon Newton's laws have become insufficient. They are now too special and too geometric, rather than general and natural. In the Universities, where courses in elementary mechanics and physics are preliminary to later education in a score of different directions, this is already palpably true. But even in the narrower curriculums of the special engineering schools it also applies. It is a shameful concept of even engineering education which considers a man to be properly equipped when he can compute the forces at work in a crane, a fly-wheel, or a projectile, or can solve corresponding problems in chemistry and electricity, and which stops there. Even the engineer must possess a broader grasp of the natural principles of equilibrium in chemical, thermal, and electrical energies, as well as his ability to compute, or he may not be called educated. He is merely mechanically trained.

To attain this broader end the student needs, not a longer curriculum of detail, but a broader and truer founding of mechanical concepts, in their energetic sense.

If Newton's laws be viewed in combination, instead of separately, and be supplemented with those of Kepler, a very different idea of the natural action of free mass is derived from that universally taught. By mere combination and re-analysis of these laws, the following results ensue, as fundamental principles:—

I. Mechanical action may be conceived only as occurring between two or more mass-portions. No single mass-portion ever manifests either force, motion, or energy. It derives its action only from reaction upon a fellow mass-portion. The energy of the action depends as much upon one mass as upon the other.

II. Force is everywhere. We cannot conceive of any mass-portion except in its relationship to other mass-portions; and in each such relationship force is manifested. No mass-portion may ever become so far isolated from its fellows as to be free from constraining force. No mass-portion may be considered as heterogeneous except force be understood as existent in its every suture.

III. Motion is everywhere. We have no idea of fixation. Motion is purely relative. It exists only between mass-portions, and not in either one of them.

IV. Motion cannot exist devoid of a force which alters it.

V. Force cannot exist, in "free" action, without producing a motion which alters it.

VI. Motion cannot exist without continuously altering the motion which alters it.

VII. Force cannot exist without continuously altering the motion which alters it.

VIII. Motion at constant velocity or with constancy of direction does not exist in nature. To place these ideas in the premises of mechanics is to found the science upon a superstition.

IX. The natural and the only relationship between every pair of mass portions in the universe is one of curvilinear motion.

The laws defining this curvilinear motion, under constantly varying force, are fairly complex when stated in geometric terms, but are quite simple when stated in energetic terms. Yet, because geometric kinematics is the current language of the profession—while energetics is not, as yet—the latter must be approached through the former.

Let us suppose the general case of two mass portions, M_1 and M_2, as shown in Fig. 1, of a known relationship. What will be their natural "action and reaction?"

Their relationship is known when the following quantities are known, viz.:—

(1) The two masses, M_1 and M_2.
(2) The distance of their separation, s.
(3) The velocity of their relative motion, v.
(4) The angle α prevailing between s and v.

From these may be computed the force of their mutual attraction,

$$F_w = c\, M_1\, M_2\, \frac{1}{s^2},$$

their momentum

$$F_m = \frac{M_1\, M_2}{M_1 + M_2}\, v,$$

and the centrifugal force of their motion about their instantaneous centres, or

$$F_c = \frac{M_1\, M_2}{M_1 + M_2}\, \frac{v^2}{r},$$

when $\alpha = 90°$ and r is the radius of circular motion. Also, $s\, v \sin \alpha =$ a constant.

In the language of kinematics, the relative path of action of the two is known to be some one of the plane conic sections, viz., either an ellipse or a hyperbola, or some one of the special cases of these which might possibly, but not probably, arise, such as the parabola, the circle, or the straight line. Speaking from nature, it is virtually only the ellipse and the hyperbola which exist. In any case the orbit of each body uses the other body for one of the foci.

In the language of energetics, the relative action of the two mass-portions consists in the conservation of their total fund of energy, but also in a constant periodic

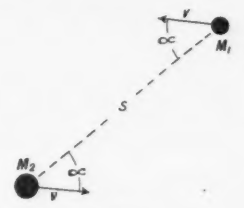


Fig. 1

transformation of kinetic portions of their energy-fund into potential form, and *vice versâ*.

But what *is* the energy-fund of the pair?

The gravitational or potential energy manifested between the two, in any alteration from a lesser separation s_0 to a greater one s_1, is

$$E_p = \int_{s_1}^{s_0} F_w\, ds = c\, M_1\, M_2 \int_{s_1}^{s_0} \frac{ds}{s^2}$$

$$= c\, M_1\, M_2 \left(\frac{1}{s_0} - \frac{1}{s_1}\right) = c\, \frac{M_1\, M_2}{s_0\, s_1}\, (s_1 - s_0),$$

which is the only completely accurate formula for potential energy.*

As pointed out in a former article, if $M_1\, M_2 / s_0 s_1 = W$ and $s_1 - s_0 = h$, then

$$E_p = Wh,$$

which is the more familiar approximate formula for potential energy.

The kinetic energy manifested in the same change is

$$E_k = \frac{1}{2}\, \frac{M_1\, M_2}{M_1 + M_2}\, (v_0^2 - v_1^2)$$

wherein the zero subscripts refer to the condition of lesser separation and greater velocity.

If M_1 be very large, relatively to M_2, then $M_1 / M_1 + M_2$ may be taken as equal to unity, and if it be assumed that v_1 may be zero, the formula for kinetic energy then becomes the familiar approximation

$$E_k = \frac{1}{2}\, M_2\, v_0^2$$

The kinetic energy gained by the pair in its alteration from s_1 to s_0, and from v_1 to v_0, is equal to the potential energy lost in the same change—both expressions being used as is now customary. But, according to these formulas, the energy-fund of the pair does not possess any absolute value. It rests upon a variable at each end. Any manifestation of energy within the pair consists solely in a change of condition, from a greater to a lesser separation or velocity of relationship, or the reverse. Is there, then, no absolute zero of energy for the pair, from which their total fund of energy may be measured as an absolute positive quantity?

It seems not. It will appear that of the two variables defining the energy-fund on its either side, neither may pass to a zero. But to understand the situation properly there must be further discussion of its details.

Let us imagine that a cannon were fired in a true horizontal direction, and that the resistance of the atmosphere were absent. After a brief trajectory, lasting a few seconds, and covering at most a few miles, the projectile must again collide with the earth, and the phenomenon is over. While the cannon-ball is pursuing its free path, as a mass-portion separate from, yet not independent of the earth, it is said to possess "mechanical energy." When collision has recombined the projectile into unity and solidity with the earth, so that they may no longer be distinguished as separate mass-portions, it is said that the energy is "gone."

In this familiar phenomenon is seen, in the first place, the fact that energy, motion, and force are features of *separateness* between two or more mass-portions, rather than of any quality inherent in either one alone. They disappear when the separateness disappears. They are functions only of the *form of relationship* between the separated masses, and not of the masses themselves. They prevail only so long as the separation continues.

In the second place, this phenomenon illustrates the temporary, evanescent character of mechanical energy. Try as we will, we can postpone only slightly the time or distance through which our projectiles, railroad trains, &c., continue to possess energy. Sooner or later they drop back insistently into fixity, into a solid recombination with the parent earth, and their energy is "gone."

Let us suppose, however, that modern artillerists, in their endeavour to prolong the trajectory and "life" of their projectiles, should succeed in multiplying present muzzle velocities by ten or twenty fold. With each increase in velocity the projectile speeds farther and farther upon its way before it again touches the earth. Soon the curvature of the earth's surface becomes a material factor in the prolongation of the flight, and, finally, when the initial velocity becomes some 18,000ft. per second, the curvature of the trajectory just equals that of the earth. Neglecting atmospheric resistance, the projectile then becomes a satellite of the earth, following a circular orbit; and if the gun had been accurately aimed, the satellite would encircle the earth within about 85 minutes, and would again enter the gun by the breech, had the piece not been meantime removed from its path.

What sort of energy is this? It certainly must still be "mechanical." At least, we possess no other name for it. Yet it is now no longer evanescent. It exists indefinitely.

Moreover, there is here involved no question of potential or gravitational energy, except in the persistence of the original fund of radial separation from the earth, which the projectile possessed when placed in the cannon. The motion is purely tangential. Nor is there any tranformation of one sort of energy into another. The potential energy remains potential; the kinetic energy continues undiminished in amount. The excentricity of orbit is zero.

A mass pair such as this projectile and the earth, embodying purely circular motion, could maintain its existence only by a perfection of balance between centrifugal and centripetal forces. That is to say,

$$\underset{\text{(centripetal)}}{c\, M_1\, M_2\, \frac{1}{r^2}} = \underset{\text{(centrifugal)}}{\frac{M_1\, M_2}{M_1 + M_2}\, \frac{V^2}{r}}$$

or

$$\frac{c}{r} = \frac{V^2}{M_1 + M_2}.$$

Accordingly, a pair possessing a larger radius must embody a lower velocity, and *vice versâ*.

In comparing the energy funds of two mass pairs then, which possess circular orbits of radii R and r respectively, it appears that the larger radius and slower velocity embodies the greater energy fund. For the space energy involved in this change of radius from r to R is $c\, M_1\, M_2 \left(\frac{1}{R} - \frac{1}{r}\right)$, the energy being absorbed as the radius increases. According to the above equation, this is equal to $M_1 M_2\, \frac{V^2 - v^2}{M_1 + M_2}$. But this last is just twice the kinetic energy which is given out by the slowing down of the pair as its radius increases. The net absorption of energy, therefore, as the radius increases

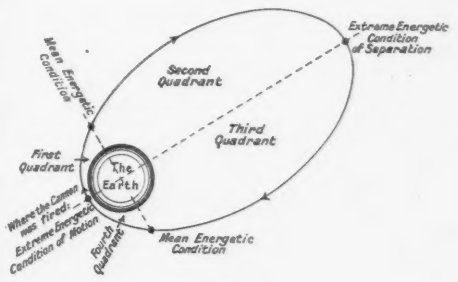


Fig. 2

with circularity conserved, is just half of the space energy involved in the same change of radius when the energy, rather than the circularity, is conserved.

As a matter of natural fact, there is no known single process whereby a pair can be gotten from circular motion of one radius to circular motion of another radius. Any energetic process applied to a circular orbit would introduce excentricity while altering the radius, in order to conserve the energy rather than the circularity. At least two processes, balanced to exactness in amount, must be applied simultaneously in order to conserve circularity; and the natural probabilities are infinitely against any such a balance. But if this balance be imagined as accomplished, the net result of a conservation of circularity would be as stated, viz., an absorption of energy as the radius increases and the velocity falls, and *vice versâ*.

It is plain from this that purely circular or tangential motion cannot be regarded as embodying energy merely by virtue of its velocity, upon the same terms as translational motion. The relation between velocity and energy

* The true formula is

$$E_p = c \int_0^{M_1\, M_2} \int_{s_1}^{s_0} \frac{1}{s^2}\, d\,(m_1\, m_2)\, ds,$$

which may be integrated into the one given, upon the assumption that the mass-portions are solid spheres.

indeed, seems to be squarely reversed. The search for the true energy fund must proceed further.

To proceed with the cannon ball illustration, let the muzzle velocity be still further increased, above 18,000ft. per second. The orbit of the projectile-satellite now acquires excentricity, and becomes elliptic. It rises highest away from the earth and passes apogee over the antipodes, returning to perigee at the point of start. Although the velocity and energy have obviously been increased, the period of revolution has lengthened, according to Keppler's law, in proportion to the two-thirds power of the major axis of the ellipse.

Such an orbit as this is portrayed in Fig. 2. It shows how the mass pair would alternate from a condition of extreme motion energy, at the point where the cannon was located, to a condition of extreme space-energy, at a point "above" the antipodes. This alternation reverses itself, in a complete vibration, once each revolution.

The increase of muzzle velocities above 18,000ft. per second might be carried to any degree with a corresponding lengthening of the ellipse and the period of revolution, until a velocity of about 32,000ft. per second had been reached. By this time the ellipse, which lengthens more than proportionately to the velocity as the latter becomes greater—because of the decreasing force of attraction as the distance of separation increases—has extended itself to an infinite length, as has also the period of revolution. The orbit has become hyperbolic. The energy imparted to the projectile by the gunpowder and stored in it in the form of motion has just been sufficient to separate the projectile from the earth completely.

Further augmentations of muzzle velocity above this point are, of course, imaginable, to any degree for which a commensurate supply of power for the start is imaginable. Such greater degrees of energy would merely increase the excentricity of the hyperbolic orbit, a process which can be extended to any degree.

Returning to the case of elliptic motion, which alone is permanent in form, there takes place at each revolution a double, or reversed, transformation of energy, from kinetic to potential and back. At perigee—or periastron, the more general term for the condition of greatest propinquity between two mass portions—the energy is chiefly motion energy. At apogee, or apastron, this has become largely space energy. Upon the return to periastron this alteration has been reversed again.

From this it is obvious that there must be, intermediate between periastron and apastron, some point where this conversion has been just half performed — where the balance is momentarily attained between motion energy and space energy. A simple application of the equations for kinetic and potential energy given above identifies this point. It is located at either extremity of the *latus rectum* of the ellipse. The two extremities of the *latus rectum*, therefore, are known as the points of mean energetic condition, just as the two extremities of the major axis constitute the two extreme energetic conditions of motion energy and space energy respectively.

A MACHINE FOR REGISTERING THE WORK OF MACHINE TOOLS.

DURING recent years many attempts have been made to determine the exact cost of details of machine-tool work, partly to enable the cost of production to be determined, and partly to give a better control of the shop work.

A registering or recording apparatus for machine tools is being built by the National Machine Recorder Company, of Chicago, and is being introduced in some large machine shops. Its special object is to reduce the time so often lost by individual operators due to starting late, stopping early, delays in setting work on the machines, and failure to operate the machines at their best capacity. The apparatus is placed in the office of the superintendent or manager, where it is constantly under inspection, and the apparatus will register for fifty tools.

A drum driven by a train of clockwork is mounted in a case or housing, with a glass panel for inspection. This is driven by a train of clockwork, and upon its face is fitted a sheet of paper for the record. The drum is 18in. wide, and of such circumference as to admit a sheet ruled for twelve hours. The sheet of paper is divided into horizontal spaces, each representing one minute. Vertical rulings form columns, each of which is for an individual machine. In a horizontal frame across the face of the drum are fifty pencils, or metallic marking points. Each one of these is operated by an electro-magnet connected electrically with one of the shop tools. The connection is made with the belt shifting lever by which the machine is started and stopped, and it cannot be tampered with by the operator. When the lever is thrown to start a machine—say No. 10—an electric contact is made, and the pencil or marker No. 10 is pressed against the sheet on the revolving drum. A line then continues to be drawn on this sheet until the lever is again thrown to stop the machine, when the circuit is broken and the marker drawn back from the drum.

The broken line or diagram on the ruled sheet will show the exact time of each stop and start, the actual working time, and the actual time during which the machine was idle. The foreman has his record of the work given to each machine, and an examination of the line drawn for any machine will show not only when the man started and stopped, but also the time occupied for each operation. To leave a machine running will not help, as the diagram would show that unnecessary time was consumed in the operation.

Many men are careless or ill-informed as to running their machines at the speed and feed most suitable to the work in hand. The record will show what time was consumed in making the roughing cut, in adjusting the machine to the finishing cut, and in making the finishing cut. It will be evident beyond dispute if the cut is made at too slow a speed or if excessive time is lost between finishing one piece and commencing the next piece. As the sheet of paper is visible, the work can be followed at any time; exceptional loss of time by a machine may be detected at once, and the foreman notified to make an investigation as to that machine. At the end of the day the amount of work done and the amount of working and idle time can be reckoned. For variable speed machines, the record will show if they are being worked to the best advantage.

With two or more machines performing similar work, the respective capabilities of their operators are made apparent by a comparison of the lines traced on the record sheet. If a man is cautioned as to his loss of time on a certain operation —either by idleness or running the machine with insufficient speed or feed—the subsequent diagrams for his machine will indicate if he is following instructions or heeding the warning. There is thus a moral effect on the men, due to their knowledge that the results of their work and time are being openly recorded in the office. In addition to this, it is estimated that greater efficiency and economy of the shop or works as a whole should result from putting the performance of each machine and machine operator under the direct observance and control of the higher officials.

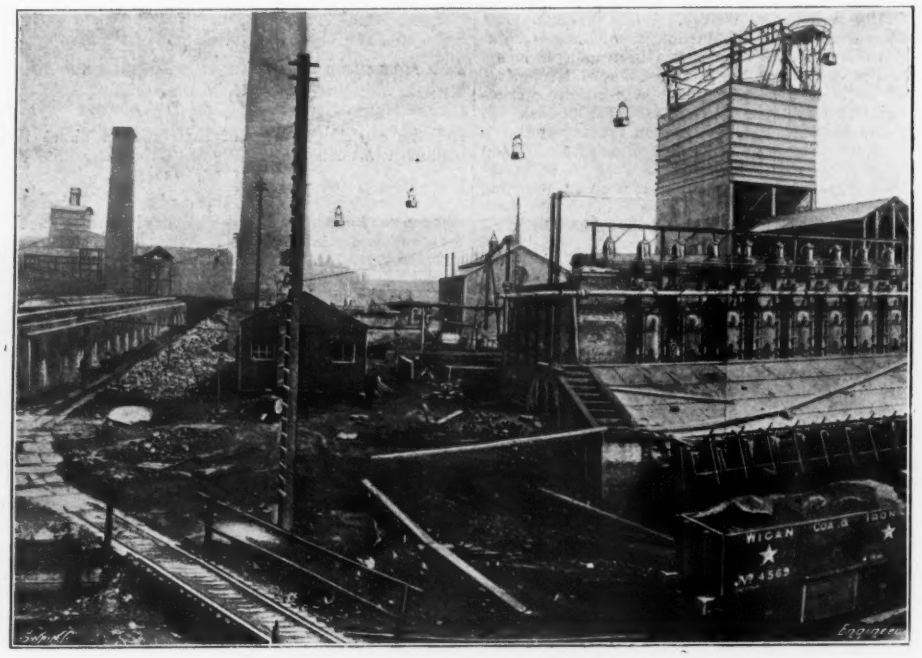


Fig. 1—COAL TRANSPORTING PLANT OF THE WIGAN COAL AND IRON COMPANY

THE EMPLOYMENT OF SUSPENSION RAILWAYS IN IRONWORKS.

THE extraordinary increase of late years in the employment of wire ropeways and suspension railways with electrical single driving is, among other reasons, chiefly due to the fact that the suspension railway can be hung at any desired height above the ground level, so that it does not encroach upon space which can be used for manufacturing purposes. The wear and tear of a suspension railway is slight, because all delicate parts are out of reach of the material carried, and cannot, therefore, be clogged or dirtied by it, the material only coming in contact with the substantially made car buckets. On the other hand, the introduction of modern improvements has made possible not only the vertical, but also the horizontal deflection of ropeway cars without detachment from the rope, whereas almost all other conveyors are confined to one level, so that the wire ropeway may to-day be called one of the most adaptable methods of transport. The consequence is that an exceptionally small staff of attendants is necessary, and the material is not unduly damaged, because it remains undisturbed in one and the same receptacle from the starting point to its destination. This applies not only to the wire ropeway, but also to the suspension railway with electrical single drive of the cars. The latter system is, in fact, far more adaptable, and requires even less attendance, because the cars can run automatically anywhere where a travelling rail and a conductor have been laid. In the electric suspension railway all pushing of the cars between the loading and coupling points becomes superfluous, because the attendant can stop the cars at any desired point and re-start them by a simple switch action. The cars must run singly and not in trains, otherwise, in consequence of the concentration of a heavy load at one point, the support would be too heavy. As a matter of fact, it is impossible to furnish a driver for each car, so that they must necessarily run automatically without colliding at the switches and crossings. The "Bleichert" patented block system fulfils these conditions, and with simplicity. If one car approaches another too closely on the open track or at crossing points, the second car is kept back, because the foremost car cuts off the current for the section in question, and not until the first is in safety can the second car restart automatically. This is of special importance at the loading station, because cars must often wait there for longer or shorter periods. The doubts first entertained by engineers in iron works that the delicate parts of an electric suspension railway would not stand rough work have been completely silenced by experience. A plant of this description has now been working

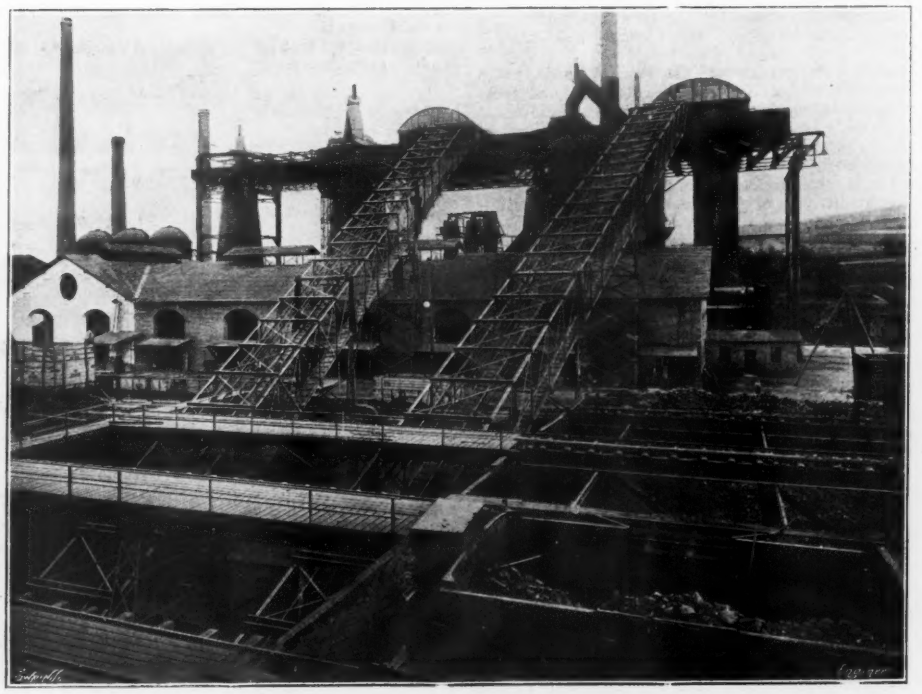


Fig. 2—INCLINE BLAST FURNACE ROPEWAY

four years on the charging platform of a furnace without its safe and good working being impaired.

The employment of various systems of suspension railways in iron works developed somewhat on the following lines:—

The first step was the introduction of wire ropeways for the conveyance of coal and ores over longer or shorter

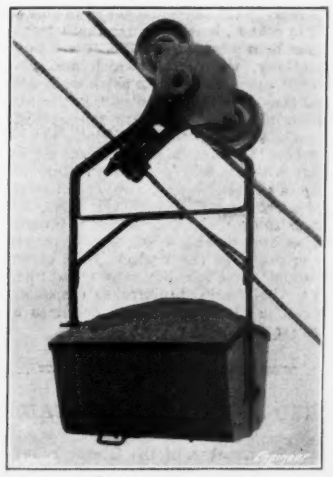


Fig. 3—AUTOMATIC COUPLING APPARATUS

distances from the mine, railway, or ship to the works. Later, the thought grew that the possibility of a suspension line crossing land otherwise employed, roads and buildings could be taken advantage of for interior transport work. A good example of a system of this description is the plant owned by the Wigan Coal and Iron Company, which we illustrate in Fig. 1. It is here a question of transporting coal from a shaft to a storage building for the coke furnaces over various intervening buildings. A simple solution was found by suspending two wire ropes of about 370ft. long between the shaft gear and the storage tower without any intermediate support. The loaded wire ropeway cars run to the storage depôt, discharge and return empty to the shaft after automatically running round a return sheave. Similarly ore can be conveyed from the shaft or coke from the coke ovens direct to the furnace. It also often occurs that the raw material arrives by rail. In this case it is now a general custom to store it in elevated hoppers instead of on open ground, and the contents are drawn off into the conveying car by simply opening an escape gate. These hoppers are generally arranged near the furnace, so that it is advisable to build a rigid bridge—as shown in Fig. 2—up to the furnace top instead of using a wire rope. Suspension cars are here drawn up by means of a traction rope, uncoupled at

Fig. 5—LOADING SUSPENSION RAILWAY BUCKETS

the top, and pushed to the furnace by the workman in charge, where they are discharged. As a rule, several furnaces are connected together by light bridges, and the furnaces served by two lines, so that one can always act as reserve for the other. With the employment of the coupling apparatus "Automat" with low-lying rope, gradients of 45 deg. and more are permissible—Fig. 3. The only imperfection in this system was the necessity of employing labour on the level of the works and at the furnace top to push the cars, although the reduction on the usual working staff was considerable owing to the short distances and the greater mobility of the cars as compared with the older method of vertical lifts and trucks. This drawback gave an opening for electrical single driving, with which the cars can run automatically from the loading point to the commencement of the ropeway, and again from the terminus of the inclined plane to the furnace. The result is that now only the opening of the hopper escape gates and the tipping of the cars require manual labour. The cars couple automatically, without stopping, to the traction rope at the foot of the gradient, and uncouple automatically again at the top. On the inclined section the current conduction is broken. This combination of electric and rope driving is of especial importance for those works in the original lay-out of which the transport of material was not the main question, as traffic can be developed according to requirements even under the most unfavourable conditions. The pockets can be put up at any distance from the furnaces and separated from them by other workshops, such as moulding shop, blowing house, &c. Generally speaking, care must be taken that materials which offer the greatest difficulties in transport must be stored or worked nearest the furnaces. With modern appliances, ores, limestone, and coke may be included among materials easily handled, whereas the conduction of compressed air and the handling of pig iron occasion much greater difficulties and expenses. The consequence is that the main points to be considered in designing new works are now very different from those of earlier days. It is now possible to give particular attention to the convenient arrangement of the casting and blowing houses, andthe transport of raw material, which had formerly a predominant interest, is now a secondary consideration.

An example of a systematic plant is the one built a few months ago by the firm of Adolf Bleichert and Co.. of Leipzig and London, for Messrs. Gebrüder Stumm, Neunkirchen, near Saarbrücken, after the system had proved a success in various other establishments. As seen from the ground plan—Fig. 4—ore and limestone are delivered in railway trucks and thrown into a number of pockets, under which the electric suspension railway runs. From here the material is drawn off into the elecric suspension railway cars by chutes with special escape gates—Fig. 5—and run first over an automatic weighing machine to the "collecting siding." Here the cars are divided, according to the various kinds of ore carried, and placed on the various lines by setting the switches, until the attendant stationed at the starting station of the wire ropeway puts them in motion by switching on the current, so that they couple on to the traction rope. The cars are now hauled up to the charging platform—Fig. 6—uncouple automatically, and are directed to the various furnaces by the attendant here in charge, who has only to set the switches correctly. The cars are then tipped over the mouth of the furnace—Fig. 7—return to the wire ropeway, and run down the rope again. At the foot all cars arrive on the section 9, running beside the hoppers to the other end of the hopper building, where, by setting the switches, they are transferred from the cross line 10 to one of the three loading sections, 1, 2, or 3. A reserve is provided by arranging the wire ropeway as a double line. These two lines, however, are not simply laid side by side, as it would in this case be impossible to avoid the rails crossing on the charging platform, but are so

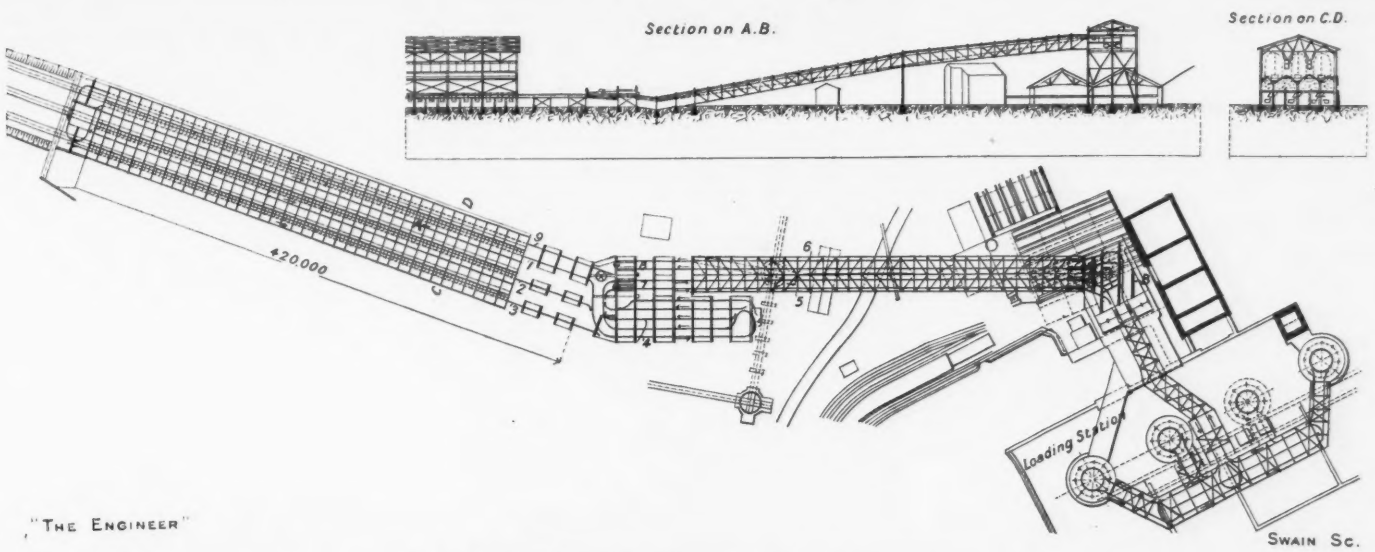


Fig. 4—PLAN OF FURNACE CHARGING PLANT AT NEUNKIRCHEN

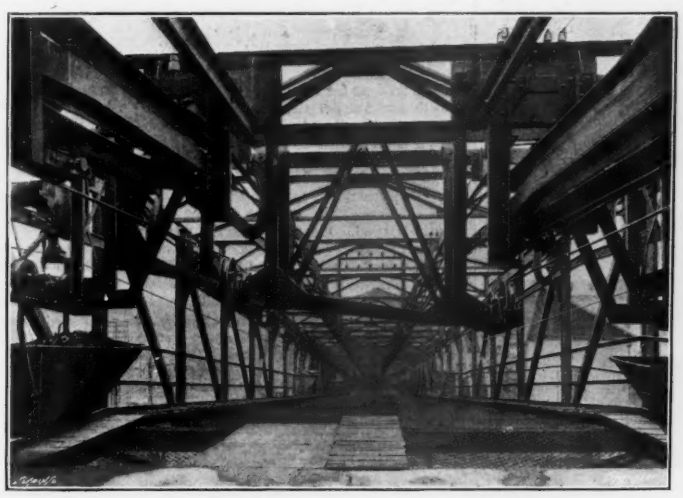


Fig. 6—INCLINED SECTION ON SUSPENSION RAILWAY

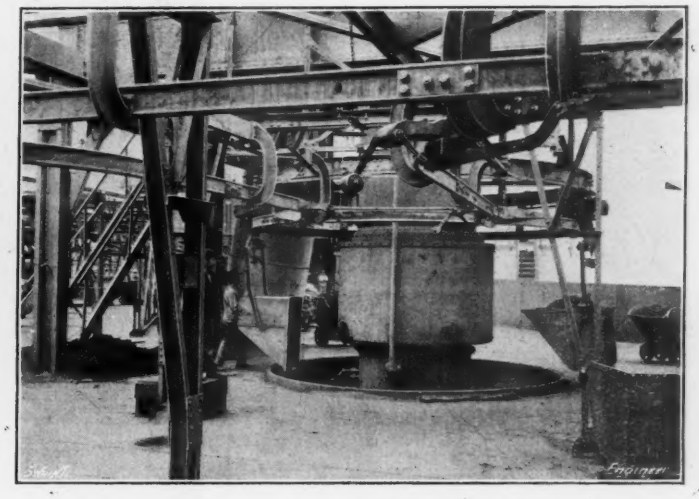


Fig. 7—TIPPING OF CARS OVER FURNACE TOP

arranged that the two tracks of one ropeway—5 and 6—lie outside, and those of the other ropeway—7 and 8—inside. Compared with the old working with vertical lifts in the "Stumm" works, there is a saving of fifty men on every shift, although for the present the new method is only employed for the conveyance of ores.

Fig. 8—TRUCK TIPPER

The transport plant of the "Maximilianshütte" in Rosenberg is still more extensive, because coke, as well as ore and limestone, are here carried by suspension railway to the furnace mouth. The greater part of the material is delivered by railway, and only a small quantity comes over a wire ropeway from a neighbouring mine. To avoid the discharge

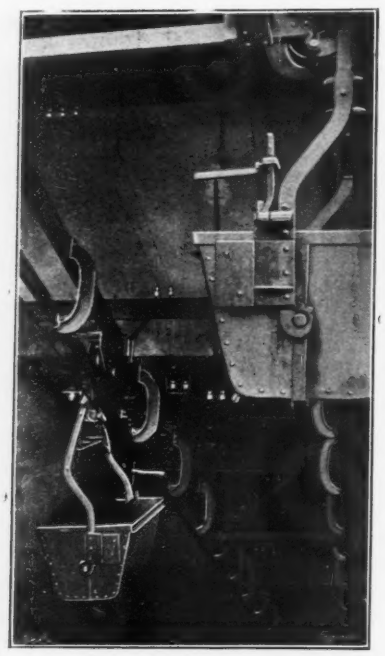


Fig. 9—TUNNEL SECTION OF SUSPENSION RAILWAY

of the railway trucks by manual labour, a "truck-tipper" was introduced, capable of emptying ten trucks in the hour. A peculiarity in the construction of this tipper, which can be plainly seen in Fig. 8, makes it possible to tip on both sides, so that trucks can be tipped in the proper

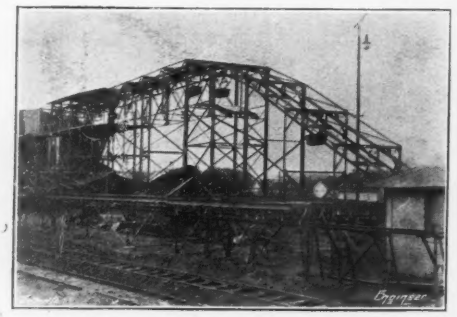


Fig. 10—SUSPENSION RAILWAY

direction without being turned. The material is drawn off from hoppers, placed at each side of the tipper platform, into the cars of an electric suspension railway, which are hauled to the height of the ore pockets from the loading station under ground level—Figs. 9 and 10—and discharged at any point desired. The wire ropeway also works into these pockets. Under the pockets a number of suspension railway lines run on which the ore cars can be loaded, as on the "Stumm" plant, and are then pushed to the starting point of one of the two inclined lines—Fig. 11—where they are

Fig. 11—COUPLING STATION OF FURNACE ROPEWAY

coupled to the rope and drawn up to the furnace mouth. At the summit, a second wire ropeway—Fig. 12—has been built to distribute the cars to the various furnaces. On this line,

Fig. 12—ROPEWAY AT FURNACE TOP

however, the main gripping apparatus of the ropeway cars is not employed, as each car is furnished with a simple catch fork, into which the rope is laid. This arrangement is said

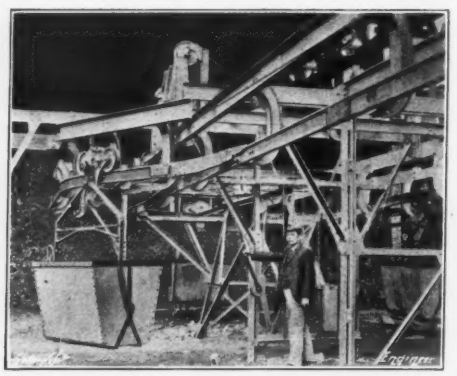


Fig. 13—RETURN STATION ON COKE LINE

to be quite sufficient for the horizontal movement, and the coupling and uncoupling of the cars before the separate furnaces is much more convenient. After the cars have been

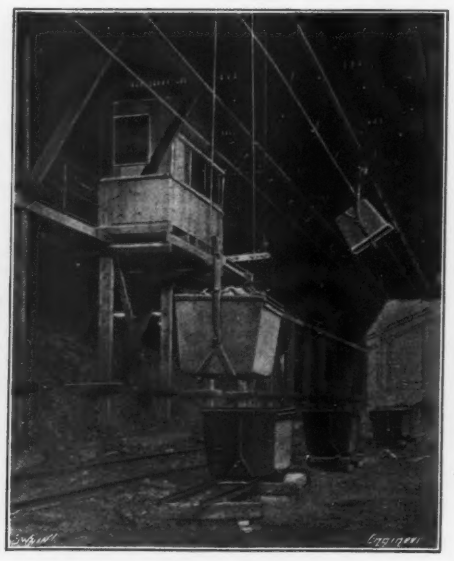


Fig. 14—SUSPENSION RAILWAY IN COKE SHED

tipped over the furnaces they return to the top station of the wire ropeway, and run down the rope for reloading. Coke is transferred direct from the railway trucks to the suspension railway cars, for which purpose a suspension railway—Fig. 13—has been arranged on the level of the works, parallel to the furnace bench, on which the cars are also moved by a rope and simple catch forks. At the point where the cars are to be loaded they are uncoupled from the traction rope by simply raising the latter, and pushed on to a travelling loading switch. The loaded cars run on the rope to the starting station of the inclined line, and are conveyed to the charging platform in the same manner as the ore cars.

The traffic in coke is, however, somewhat irregular, so that a coke shed has been provided which is served by an electric suspension railway, the cars of which are provided with winches and controlled on a system patented by the firm Adolf Bleichert and Co. The suspension railway cars are loaded in the shed from the railway trucks, raised—Fig. 14—and immediately carried over the storage depôt, which is crossed by a number of suspension railway tracks. At any desired point a striker is placed, which effects the automatic tipping and emptying of the car buckets. The coke line on the level of the works is also connected with this shed, so that it is also possible to convey from there direct to the inclined line. The system as here described can also be employed when the coke is produced in the works. It is claimed to be quite immaterial what position the coke furnaces have with regard to the blasting furnaces, as the electric suspension railway can be led between other buildings and storage places just as required.

SHAFTING AND COPPER PIPE FAILURES.

ADDRESSING the members of the Greenock Association of Engineers and Shipbuilders in the Watt Memorial Hall, Greenock, on December 10th on the subject of "Wear and Tear of Machinery," Mr. W. R. Austin, of Lloyd's *Register of British and Foreign Shipping*, referred to three factors as having direct bearing in this connection, viz., material, design, and workmanship. He instanced the case of an iron shaft as involving the first and last of these. In building from common scrap it was almost impossible to keep perfectly free from flaws, this arising from the difficulty of cleaning the scrap, even with the best shingling appliances. On the other hand, if rolled bar iron is used a shaft is obtained which, if it has not the uniformity of structure or homogeneity of steel, is more fibrous and less liable to failure from the combined actions of fatigue and the corrosion of seawater. Referring to solid and "built" shafts, the author stated that there must be many engines working at present with crank shafts slightly out of line, yet failures in built shafts are comparatively rare; and everything goes to show that the usual working stresses which would have necessitated the renewal of a solid shaft are borne by a built one without injury. In a solid shaft the power is transmitted solely through a comparatively rigid material; in the case of the built crank shaft, neglecting the key or dowel-pin, it is transmitted by what he might call the dormant force of contraction. Referring to the duties and quality of copper steam pipes, the author said that those in steamers of the cargo or "tramp" class, which run much in light condition, frequently give way close to the flanges. The causes which conduce to this may in not a few instances be due to faulty design. Copper being an expensive material, it is the effort of the designer to put in as little as is consistent with efficiency. If the pipes stand until the guarantee expires, this is considered by some as good enough. He held that in hundreds of cases the bends fitted to steam pipes do not fulfil their missions, and even when they are of the easiest kind, and of the best design possible, they have been known to fail. Bends should as much as possible be discarded, and a carefully made expansion joint fitted in their stead. This would result in a large decrease in the number of failures, and give an arrangement which would be more creditable to the builder and less expensive to the owner. If it be compulsory to fit bent copper pipes, then he would suggest that the face of the flange which receives the thrust, or vibration, should always be placed parallel with the face of the flange which transmits the movement from the engine. This would largely eliminate the transverse stresses which produce fatigue and ultimate failure. He was sure that 95 per cent. of the steam pipes that had failed would never have done so had expansion joints been used instead of rectangular bends. The author then brought many other parts of machinery under detailed review, with particular reference to the methods by which defects were frequently found out.

THE ROSYTH NAVAL BASE.

THE tenders for the construction of the new naval base at Rosyth are due for delivery on the 22nd inst. The period allowed for the completion of the works included in the contract is seven years, but the Admiralty will pay a substantial bonus to the contractor if the works are completed within the stipulated period, this bonus being calculated on the number of months by which the delivery of the work is expedited. There is no limit to the amount of the bonus which may be earned. On the other hand, the contractor is liable to a penalty if the completion is delayed beyond seven years.

We understand that the following firms have been invited by the Admiralty to tender for the works:—Messrs. Sir John Jackson, Limited; S. Pearson and Son, Limited; John Aird and Co.; Topham, Jones, and Railton; L. P. Nott; Price and Reeves; Punchard, Kidd, and Williams; Perry Bros.; Easton, Gibb, and Co.; C. H. Walker and Co., Limited; Walter Scott and Middleton; Baldry and Yerburgh; W. Hill and Co., and J. D. Nowell and Sons, all of London; Messrs. Holme and King, Limited, Liverpool; Messrs. J. Young, Limited; R. McAlpine and Sons; C. Brand and Son; and Morrison and Mason, Limited, all of Glasgow; Mr. T. Best, Edinburgh; and Messrs. J. Shellabear and Son, Plymouth.

THE INSTITUTION OF CIVIL ENGINEERS: ASSOCIATION OF YORKSHIRE STUDENTS.—The fourth ordinary meeting of the session will be held this evening at 7.30 p.m. in the Department of Applied Science, room No. 12, the University, St George's-square, Sheffield, when Mr. A. H. Jameson, M.Sc., A.M. Inst. C.E., will read a short paper on "The Grindleford to Rowsley Section of the Derwent Aqueduct."

RAILWAY MATTERS.

THE Italian *Gazzetta Ufficiale* of 27th November contains a notice granting a concession to the "Societa Anonima d'Entreprise Generale de Travaux" for the construction of a steam tramway from Castiglione delle Stiviere to Lonate and Desenzano, and a branch from Montichiari to Carpenedolo and Castiglione delle Stiviere.

THE railway collection at the Leicester Corporation Museum has been completely re-arranged, and on Thursday, the 10th inst., a special meeting of the Railway Club was held to view the collection. The members of the local branch met at the Museum, and Mr C. E. Stretton explained to those present the technicalities of the various articles.

THE last spike of the Singapore-Penang Peninsula Railway was recently driven home by the Sultan of Johore, in the presence of Sir John Anderson, the Governor, and Rajah Muda of Sarawak. The Johore section of the railway is 121 miles in length, and cost 1¼ million sterling to construct. It opens up an enormous rubber country.

IT is stated that the New York, New Haven and Hartford Railroad Company has applied to the Public Service Commission for permission to electrify its branch of six tracks between the Bronx and New Rochelle on the same system as that now in operation on the New Haven main line between New York and Stamford, Connecticut. The cost of the new project is estimated at £3,000,000.

THE want of a subway for foot passengers between the British Museum Station of the Central London Railway and the Holborn Station of the Great Northern, Piccadilly and Brompton Railway has been much felt, but as the two stations are over 100 yards apart and are at different levels, nothing has been done in the matter. It is now announced that a connecting subway is to be constructed, and in it is to be provided a moving platform. The passengers wishing to change from one station to the other will only have to step on the platform, and they will be speedily carried to their destination.

A STUDY of the reliability of automatic block signal operation has recently been made by the Baltimore and Ohio Railway, the records of signal operation on that system showing for the past seven years a continuously decreasing percentage of failures. In the early years of signal operation on the system the percentages of failures of signal movements ranged from 0.32 down to 0.08, while during the past three years they have decreased to 0.04 and to 0.02. In the first six months of this year, with 478 signals in use, there were a total of 5,983,619 perfect signal movements and but 281 failures, a percentage of efficiency of 99.98.

THE *Elektrische Kraftbetriebe und Bahnen* describes an electric locomotive now being used for goods work by the Brooklyn Rapid Transit Company. It is fitted with two trolley arms, which are designed for working with heavy currents. Four motors, each having a capacity of 600 horse-power, are provided. The driving wheels are 3ft. 1¼in. in diameter, and the gauge is slightly wider than standard. The total length of the locomotive is 31ft., the height 13ft., and the weight 57 tons. It is built entirely of steel and is provided with Gould couplings. The control is on the multiple unit system. This engine is designed to draw heavy trains at a speed of 18¾ miles per hour.

IT has been decided to construct a new section of the Rhodesian Railway between Gwelo and Blinkwater, on the borders of the Victoria district. This section which has a total distance of 52 miles, will tap a very rich agricultural country and also traverse a mining district. Work on the section has already begun, and it is expected that the whole line will be finished within a year. The capital necessary for the line has been promised by the Beit trustees out of the amount left by Mr. Beit in his will for African railway construction. The new line will connect with the Cape to Cairo Railway at Bulawayo.

A NEW railway, to be known as the Accra-Akwapim Railway, will be constructed at once from Accra, on the Gold Coast, a distance of thirty-eight miles, into the interior to Mongoasi. The gauge of the railway will be 3ft. 6in. Rails weighing 45 lb. per yard will be used and will be laid on steel sleepers. All stations will be built of cement concrete and the bridges will also be made of concrete. Easy gradients are provided, the ruling gradient being 1 in 80. There is at present a short railway at Accra, connecting some quarries with the site of a breakwater, which is being constructed there. The new railway will commence at a junction with the harbour line. The cost of the railway will be more than £200,000, and surveys have been made for an extension of the line into the interior.

THE *Frankfurter Zeitung* of 30th November states that there is at present before the Uruguayan Chamber of Deputies an important Bill for the construction of a section of railway which will have the effect of linking up the port of Colonia with the Brazilian railway system. It is proposed that the line shall begin at Colonia, and proceed through Trinidad—Uruguay—crossing at this point the Central Railway at Durazno. It will then follow this line to Carmen, thence branching off to Cerro Chato in order to pass over the river Negro, and continue onwards to join the main Brazilian line, which runs through the State of Santa Catharina. This will ensure a direct route between Rio de Janeiro and Montevideo, and the journey will be reduced to four days. Concurrently with the above project, it is proposed to carry out considerable harbour improvements at Colonia, so that ocean vessels may come up to the railway landing-stage.

DURING November all the great Canadian railways came before the public notice, the Canadian Northern and the Canadian Pacific by the opening of important new branches, and the Grand Trunk by the commencement of electric haulage in the St. Clair Tunnel. On the 4th instant the Canadian Northern Railway started its service on the Brandon-Regina line, 225 miles long, which parallels the Canadian Pacific a few miles to the south of it. The Canadian Pacific line from Yorkton, Sask., to Leslie, Sask., 66 miles, and also the 91 mile section from Moose Jaw, Sask., to Outlook, Sask., were also opened on the same date. On the 12th instant the Grand Trunk Railway formally accepted the electric haulage system in the St. Clair Tunnel and the terminal yards Sarnia and Port Huron. This tunnel electrification is the largest and most difficult yet attempted. At the official function the leading railway officials of the Continent were present.

THE use of wire netting spark arresters in the early locomotives, states the *Railway News*, began in the chimney, and gradually came lower and lower until it took the general form of a screen extending across the smoke-box near the centre and below the exhaust nozzle, which arrangement does away very largely with the tendency to rust. A semi-circular piece of netting in front completes the device. This has been greatly improved upon by constructing the netting in the form of a hopper, it being attached to the deflector sheet by pieces of angle iron, and held on the sides and front by angle iron strips. The extended sloping sides of the hopper-shaped device not only present a more ready angle of entrance for the escaping smoke and gases, but also provide a much larger space for the same purpose. It is an important feature in the construction of smoke-box screens that the amount of opening in the netting should at least equal the area of the chimney. It is generally more. The opening in wire netting or perforated plates being generally more than half of the entire surface of the material, a comparison between the chimney area and the area of the netting can readily be made. The exact fitting of the netting of perforated metal around the steam pipes and exhaust pipe is of the utmost importance.

NOTES AND MEMORANDA.

THE production of pig iron in Germany in September was 928,729 metric tons, as compared with 1,091,020 tons in September, 1907. The total production of pig iron in the first nine months of the year was 8,924,665 tons, against 9,688,484 tons in the first nine months of 1907, a falling off of 763,819 tons.

REINFORCED concrete fences and stock pens are being used at the Union Stock Yards in Chicago. The fence adopted for general enclosures consists of two reinforced slabs for each post, between which are inserted ribbed-rail slabs blocked up to proper separation, and over their tops a reinforced channel-shaped cap, which binds the two halves of each post together.

IN some recent battery installations it has been found advantageous to cover the bare copper conductors with a thin coating of cylinder oil, states *La Revue Electrique*. The oil must be strictly neutral, and is applied with a rag dipped in it after the conductor has been thoroughly dried. The coating should be replaced every three or six months, and then forms the best protection against sulphuric acid. Another point arises in connection with the attachment of thinner conductors to insulators. This is often done with copper wire, but is much more safely carried out with impregnated jute tape.

AN unusual travelling jib crane is in operation at the Burnside shops of the Illinois Central Railway for lifting and transporting wheels and axles between the locomotive pits of the erecting shop and the wheel lathes and storage section of the machine shop. It has separate electric motors for the travelling motion, for swinging the jib, which is of 15ft. radius, for the trolley traverse on the jib, and for the hoisting motion, the maximum lift of the hook being 10ft. It travels on a mono-rail track at one side of the erecting shop, and has an operator's carriage at the side of the base.

WHEN calculating the size of the generators and cables for coal mines, the power factor should not be taken at above 0.75. In spite of this, however, induction motors are admirably suited for colliery work, more particularly so for gaseous mines. If continuous-current motors are employed in fiery pits they must be of the totally enclosed type, for the chances of sparking are too great to allow of open type motors being used. The employment of totally enclosed motors means that they must be large, otherwise the temperature rise will exceed the limit, which will, sooner or later, ruin the installation and result in a burn-out.

A CONCRETE pavement of the Hassam type has been laid in Rochester-street, Boston. It is 6in. thick, the bottom 4in. being No. 1 crushed stone, well rolled and given two coats of Portland cement grout. On this foundation was spread 1½in. of No 2 crushed stone, well rolled and given two coats of grout. This was again rolled, and a ½in. coat of equal parts of cement, sand, and screenings, made into a creamy grout, was spread over the surface. An expansion joint filled with asphalt was made along the line of the curbstone and at intervals of not more than 100ft. across the street. The area of the pavement is 1129 square yards, and it was laid under a five-year guarantee. The cost was £396, including excavation.

SOME experiments have recently been carried out by Herr E. Mattenklodt with a view to investigating the effect of high-voltage gradient and of temperature on the specific inductive capacity (S.I.C.) of mica. The *Elektrotechnik und Maschinenbau* states that he finds that even up to voltage gradients as high as 600,000 volts per centimetre no variation as great as one part in 100,000 occurs. There is, therefore, no similarity between the dielectric action of mica and magnetism in iron, and no true dielectric hysteresis appears to exist, since this is incompatible with constancy of the S.I.C. No variation of the S.I.C. with temperature for variations of 30 deg. could be detected. The actual value of the S.I.C. is indefinite. Variations in the chemical composition—for instance, the amount of water contained—appear to be of great importance. The values formed for the S.I.C. lie between 7.1 and 7.7.

THE German Association of Electrical Engineers has a code of rules and specifications to which all fuses must conform when new. The fuses constructed by the leading electrical manufacturers of Germany fully comply with these requirements. There has, however, come into existence a large number of firms making a special business of repairing fuses. Notwithstanding the reassuring nature of their prospectuses, the work done by these firms is usually of a most inferior character. The evil has grown to such proportions that a special committee has made a large number of tests of "repaired" fuses. So great a danger attaches to the use of fuses "repaired" by irresponsible firms that the German Association of Electrical Engineers is taking steps to require that all repairing of fuses shall be done by the original manufacturers, as this measure appears best calculated to ensure that the repaired fuses shall comply with the Association's requirements.

THE chief of the countries from which chemicals were imported into Syria during 1907 was Germany, while the next countries, says the *Chemische Industrie*, in the order of the importance of their supplies (value), were France, Belgium, England, and Italy. Belgium led with regard to zinc white. England led in lacquers and varnishes. The indigo business, which is declining, was done direct with India, whilst the continuously increasing demand for synthetic indigo was entirely satisfied by Germany. The importation of dyewoods, usually done through English and French houses, has declined from 250 dz. in the preceding year (1906) to 14 dz. only in 1907. Italy has begun with success to compete with England and Germany in the quinine business. Sulphuric acid and green vitriol were got exclusively from England. England and Belgium shared the soda business between them, and Belgium was the only furnisher of potash.

SIXTY-FOUR samples of petroleum oils, ranging from heavy crude oil to gasoline, and representing the products of the principal oil fields of the United States, were examined for calorific power by combustion in oxygen in the Atwater-Mahler bomb calorimeter with results ranging from 10,318 to 11,733 calories per gramme, or 18 572 to 21,120 B.T.U. per lb. In general the decrease in calorific power with increase in specific gravity was fairly regular, so that the relation between the two may be expressed approximately by means of the simple formula B.T.U. = 18,650 + 40 (B − 10), in which B = degrees on the Baumé hydrometer. When the calorific powers calculated from the densities by means of this formula were compared with those actually determined, it was found that in one-ninth of the cases the difference was greater, and in eight-ninths it was less than 1 per cent.; in only one-thirtieth was it greater than 2 per cent.; in no case was it as great at 3 per cent.

A PAPER on the volatile matter in coal, embodying the results of the investigations of Messrs. H. C. Porter and F. K. Ovitz, of the United States Geological Survey, was read at the June meeting of the American Chemical Society. The conclusions of the authors are as follows:—(1) Some coals liberate gas during storage of a composition similar to that of natural gas, and some coals rapidly absorb oxygen from the air during storage without forming CO_2. (2) During drying in air at 105 deg. Cent. some coals lose appreciable amounts of CO_2, and most coals take up oxygen to a considerable extent, but none of those tested show any considerable formation of combustible gases. (3) The nature of the volatile products distilled from several coals at low temperatures in the early stages of heating varies in different coals in accordance with their smoke-producing tendency. (4) The volatile matter of coal comprises a considerable proportion of non-combustible matter varying with the type of coal.

MISCELLANEA.

THE Admiralty have intimated that until more experience is gained in night fire control, the position of the searchlights in any of his Majesty's ships may be altered as considered necessary by the commanding officers, provided the work can be carried out by the ships' artificers. Commanding officers are to forward a report whenever any such alterations are carried out.

THE demand for suction gas plants for mines in outlying districts continues, and it would appear that it is far more likely to increase than to decline. From all we can gather, states a contemporary, equipments of this pattern are running satisfactorily all over South Africa. The latest Transvaal mine said to be likely to use a suction gas plant is the Louis Moore, in the Zootpansberg.

REPLYING to a deputation from the Southampton Harbour Board and Borough Council, who met the directors of the London and South-Western Railway last Tuesday, to urge that the railway company should construct its proposed new graving dock at Southampton instead of at Woolston, on the other side of the Itchen, Mr. S. W. Drummond, deputy chairman of the railway, explained that the site had been selected from among four available ones, after mature consideration. He did not share the fears of some that a graving dock at Woolston would be injurious to Southampton, and he instanced other ports where it had not been possible to confine development to any particular side of the water. The directors, however, would consider the views put before them, and report their decision in due time.

WE hear that Mr. Carnegie's assertion that American steel manufacture was so little in need of protection that the cost of making steel in the United States was, in fact, much less than the cost in any other country has been corroborated by the officials of the Steel Trust in cross-examination. Before the House Committee of Ways and Means, which is hearing the views of representative men on the tariff question, Mr. Charles M. Schwab, president of the Bethlehem Steel Company, verified a letter he wrote on May 16th, 1899, when president of the Carnegie Steel Company, to Mr. Henry C. Frick, saying that steel rails were then being made at a cost of less than £2 8s. per ton, nearly £1 8s. less than the cost of production in England. Mr. Schwab added that the present cost of making steel rails was £4 6s. per ton.

OPENING the new Wireless Post-office Station at Bolt Head, near Salcombe, last Friday, the Postmaster-General said the principal objects in erecting the station were to carry out the obligations thrown on the Post-office by the Radiograph Convention of 1906, and to see that the other parties to the Convention carry out theirs also, and, more important, in pursuance of the deliberate policy of the Post-office that nothing in the nature of a monopoly should be allowed to grow up in wireless telegraphy. He was convinced that wireless stations had a very great future. The Post-office always desired to be in the forefront in matters affecting communication, and were entitled to self-congratulation on that station. Sir Babbington Smith also spoke, and messages were sent by wireless telegraphy to the Admiralty, Guernsey, Alderney, Ushant, and other places.

AT the Royal Society of Arts recently, Mr. Eric Stuart Bruce, lecturing on "Mechanical Flight," pointed out that in practical aëroplane travelling there will be two great difficulties to be overcome—starting and stopping in the air. He suggested that possibly the future flying machine might consist in the combination of the aëroplane and lifting-screw systems, as there would undoubtedly be an advantage in retaining the aëroplane surface in case of falls, even though it may not be adjusted to support a certain weight. Mr. Bruce insisted that in experimental flights the operator should be provided with a parachute, which will probably in future come to be regarded as the lifebuoy of the flying machine. Even in its partially developed state, he thought the aëroplane might prove to be a potent factor of war, and in that case the skill of the British engineer must be largely diverted from the ocean to raising defences in the air.

THE Aëronautical Society of Great Britain has now acquired its own experimental ground, which will be opened for the use of members at an early date. The site selected, near Dagenham Station on the London, Tilbury, and Southend Railway, is well suited for aëronautical work, as it measures some half-mile in length by about the same distance in width. The greater part of it is flat, and suitable for experimenting with full-sized machines, but on a portion to the south there are steep mounds, some 50ft. high, well fitted for testing models of all kinds. Sheds to accommodate full size machines will be erected, and as soon as funds are available a properly equipped scientific establishment containing whirling table and other aëronautical testing apparatus will be provided. The ground will only be open to members of the society and their friends, and every effort will be made to enable experimenters to carry out their work in comfort. The society has been working in the cause of aëronautical science for over fifty years. The acquisition of a really good experimental ground will undoubtedly help to develop the objects for which it exists.

CLEANING lead furnace crucibles from metallic accretions is effected at the smelting plant of the St. Joseph Lead Company at Herculaneum, Mo., by means of dynamite. In these furnaces the accretions of copper, iron, &c., entirely shut off in time the flow of lead through the lead well. The common method of mechanically removing these accretions is laborious, and usually requires the shutting down of the furnace. In the method devised by Mr. J. O. Bardill, mechanical engineer of the plant mentioned, a bomb constructed of standard pipe fittings—one 1in. nipple 4in. long, two couplings and two plugs—is lined with sheet asbestos with shredded asbestos at each end, charged with about one-seventh of a stick of 60 per cent. dynamite, attached to one end of a long iron rod, and introduced into the crucible through the lead well. The insertion is made while the furnace is in operation, and the time elapsing before explosion is given as from 15 to 25 seconds. In a description of this method published in the *Engineering and Mining Journal* for October 17th, 1908, it is stated that one bomb is usually sufficient to re-establish a perfect circulation, and that the damage to the crucible itself is very slight.

IT has been suggested that, inasmuch as navigation of the air by aëroplane is now an accomplished fact, the next thing will be to pass laws regulating the proper use by aëroplanists of the newly-conquered empire. This has already been done in the past for balloonists. In 1871, when French balloons from beleaguered Paris were dropping in Prussia, a royal decree declared them confiscate as contraband of war; and on the conclusion of peace a measure was passed through the German Reichstag which forbade, under penalty of death, any future similar aërial violation of German territory during time of war. So long ago as 1830, again, balloon ascents were made illegal in Turkey, so far as regards Constantinople and 40 miles around, and in 1872 the prohibition was extended to include the entire Turkish empire. To France, however, belongs the distinction of having made the first laws for the regulation of aërial traffic. In 1874 it was decreed that nobody should be permitted to go up in a balloon "or any other kind of aërostatic machine" which was worked by burning spirits of wine, or any other means of making a fire. Later, it was enacted in France that henceforth no balloon, whether free or captive, should be permitted to ascend with any species of furnace or stove; that no one should be allowed to ascend in a balloon unless he carried a parachute; and that ascents were not to be begun later than one hour before sunset nor earlier than an hour after sunrise. Furthermore, no ascents whatever were to be undertaken during the garnering of the harvest nor for six weeks prior thereto.

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(For description see page 651)

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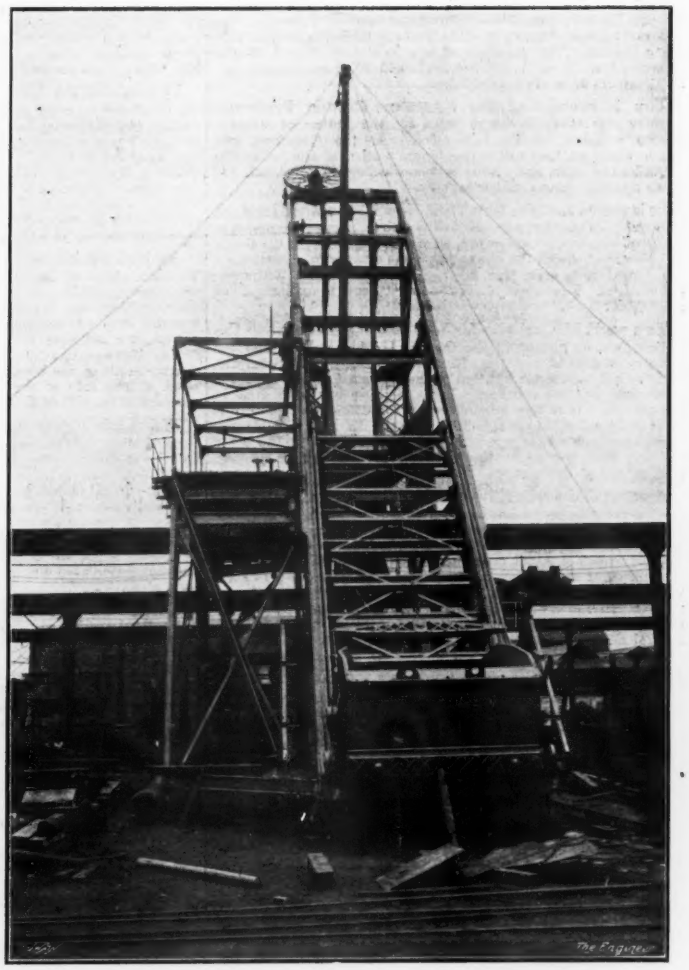

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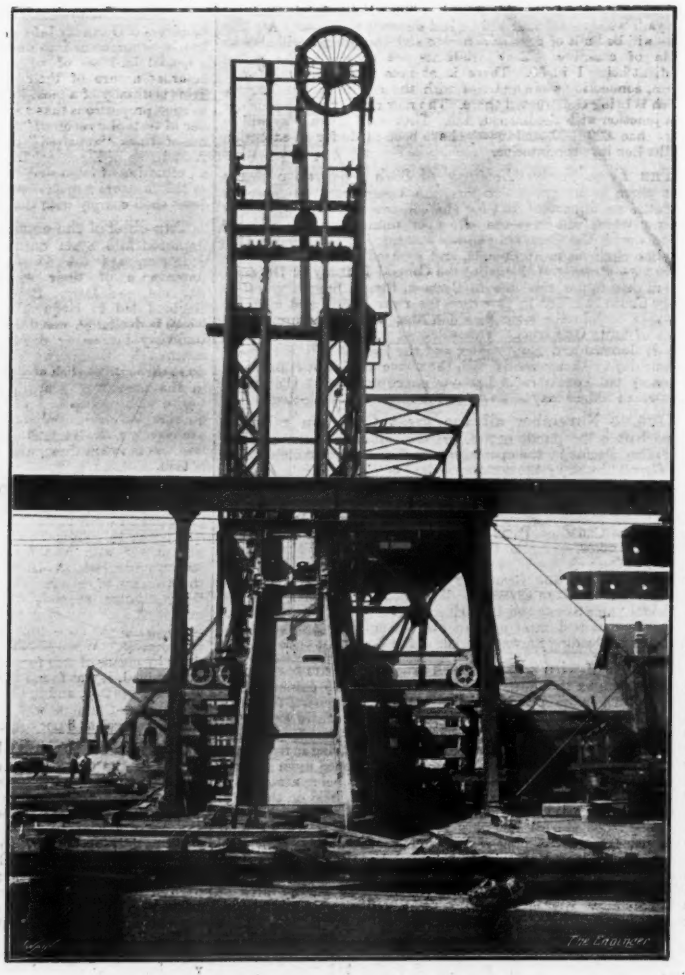

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Advertisements cannot be inserted unless delivered before Five o'clock on Thursday evening, and in consequence of the necessity for going to press early with a portion of the edition ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

Telegraphic Address, "ENGINEER NEWSPAPER, LONDON." Telephone—No. 13352 Central.

PUBLISHER'S NOTICES.

EARLY PUBLICATION NEXT WEEK.

*** *Next week* THE ENGINEER *will be published on* WEDNESDAY, *instead of* FRIDAY. *New Advertisements should reach the Office not later than Five o'clock on Tuesday evening; alterations to Standing Advertisements before One o'clock on Monday afternoon.*

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the Paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

B. (Burton).—You will be able to get some information from a book called "Multiple Cost Accounts," by H. Stanley Garry. This book is one of "The Accountants' Library" series, and is published by Gee and Co., of 34, Moorgate-street, E.C., price 3s. 6d. net. We published a series of articles by W. O. Horsnaill on "The Organisation of an Engineering Works," one of which may prove useful to you. It appeared in our issue for January 26th, 1906. We do not know of any book dealing solely with the card system applied to production costs for a general engineering works.

B. T. (Bristol).—There are several suction grain elevators in use in this country, most of which are made under the Duckham patents. This system was described in THE ENGINEER for 19th February, 1897, and the 8th April, 1898. Messrs. Haviland and Farmer claim to have improved the Duckham system. In the issues referred to above we described a plant erected by the Millwall Dock Company. We understand that the Duckham system is extensively used on the Hamburg-American line of steamers, the plants having been built by Luther, of Brunswick. We suggest that you apply for further information to the Duckham-Haviland Elevator Syndicate, of Suffolk House, Laurence Pountney-hill, E.C.

ERRATUM.

Supplement to THE ENGINEER, December 11th, page vii., for "The Liverpool and Manchester Railway opened in 1829" read "opened in September 1830."

MEETINGS NEXT WEEK.

INSTITUTE OF MARINE ENGINEERS.—Monday, December 21st, at 8 p.m., at London Institution, Finsbury-circus. Discussion.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 22nd, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Paper, "An Investigation of the Heat Losses in an Electric Power Station," by Frank Huntingdon Corson, Assoc. M. Inst. C.E.

THE FARADAY SOCIETY.—Monday, December 21st, at 8 p.m., in the Library of the Institution of Electrical Engineers, 92, Victoria-street, S.W. Ordinary meeting. Paper, "The influence of Cheap Electricity on Electrolytic and Electrothermal Industries," by E. A. Ashcroft, A.M.I.C.E., M.I.E.E.

DEATH.

On the 10th December, 1908, at his house, "The Grange," Hanley Swan, Worcestershire, WILLIAM MAYLOR, M. Inst. C.E., M.I. Mech. E., in his 80th year.

THE ENGINEER.

DECEMBER 18, 1908.

Labour Statistics.

IF ever there were a chance to redeem the labour statistics of the Board of Trade from their inherent dryness it is to be found in the condition of employment at the present moment. One might almost have expected that even the mechanical brains of the people who year by year string together the returns of employment would have been moved by the events of the moment, and that those dull statisticians would have endeavoured to give their skeleton some air of reality. But there are no Owens amongst them. Figures are figures to them and nothing more, and no effort of the imagination—the thing is unknown at Whitehall—ever inspires them to construct any living thing out of the bag of unassorted dry bones which they annually gather. And yet if any one with time and capacity would but take these tables—there are several series of them—even for a single year, and would collect and collate and compare, what a volume of priceless truths might be won from them. The facts are there, hidden behind a curtain of figures. We might trace the rise and decline of trades in various localities; we might see the reflection of wars, and witness the effect of changes of Government. The progress of invention and science is written there, enterprise and resource leave their mark, and even the weather is duly recorded. The failure of the American crops, the success of the French vintage, make their impressions on these statistics as surely as the friction of a sinew wears a groove in a bone. And on every page we may read the greatest lesson of the economics of trade—that employment never rests but swings to and fro like a pendulum; that there are great waves of commerce alternately raising industry to enormous heights, and then lowering it again on to bed rock. All these things and more are written upon these bones. Absorbing facts and truths are engraved upon every fragment, but no man arises to expound the meaning, and the dry bones remain dry bones and nothing more, year after year, to the end.

One of the most instructive tables in the last "Abstract of Labour Statistics" is also one of the shortest. It gives us the Index Numbers of Employment for every year from 1860 to 1907. The year 1900 is taken as the standard; its index is 100, and according as the employment is greater or less in other years the index is greater or less than this number. In studying this table we are impressed by two facts—first, that the ratio between full employment and great lack of employment is astonishingly small; and, secondly, that the period of the industrial wave is from ten to twelve years. Let us, in the first place, examine the latter. In 1900 employment was 100; ten years earlier it was 100.8. In 1882 it again touched a maximum, attaining 100.5, and ten years further back it stood at 102. In 1860 it was 101. Between each of the pairs of years named it declined, so that we get a wave with the crests at 10, 8, 10, 12 years apart. We have, however, one curious exception. The years 1864-5-6 should have been at the bottom of a wave; but as a fact they were all high, and for 1865 the index is 101.1. There is, of course, a reason for this remarkable fact. As it stands it is one of the dry bones of which we have spoken. Some touch of history might charm it into life; wars were rife before and about that time, they no doubt had their effect; possibly anticipation of the conclusion of the struggle between the North and South gave an impetus to trade, stopped the pendulum, and returned it to its highest point five years before its time. Possibly the real reason might be found further back if there were any records to help us. That there was some definite cause for this departure from the normal period of oscillation we do not doubt, and we do not think the exception weakens the probability of the period being about ten to twelve years long. May we then measure the future with the same rule? In 1900 employment was 100, in 1904 it had fallen to 95.9, and in 1907 it had risen to 98.5. Up to that point it had behaved normally, and although the present year may prove to be exceptionally low, we have little doubt that before 1912 100 will have been reached again. Let us now look at the hollows of the waves. Still taking 100 as the normal, we find that the bottom of unemployment is touched at 91.9, but normally does not exceed 95. That is to say, that the difference between a first-class year and a very bad year is only 5 per cent. We are helped to a better understanding of this figure by consulting other tables. But they do not go far back, and we have to be content with few examples. The percentage of trades union members unemployed in 1900 was 2.9; in 1904, with an index of 96, unemployment was 6.5. According to authorities 2.5 per cent. may be regarded as normal unemployment amongst unionists. Subtracting this from 6.5 we have 4 per cent. as the exceptional unemployment of 1904, which agrees exactly with the 96 of the index number. We may take another interesting comparison. In our standard year over thirty-six million barrels of beer were drunk in the United Kingdom; in 1904, the other year of comparison, 34¼ million barrels were consumed. The difference is equivalent to about 5¼ per cent., from which it would appear that the consumption of beer is a fair but rather exaggerated index to employment. Consumption of commodities, moreover, must be corrected to so much per thousand of population.

Wherever we turn to the tables in this volume the same fact stares us in the face. Demand is liable to cyclical changes. That is a fact that must be grasped. There is no getting away from it, no shirking it. Whatever we may do to increase our machinery or improve our workpeople, however much we may advance in the management of markets and the regulation of industry, the same fact will always remain, that demand will fluctuate, and unless we can adopt some method of controlling it employment must fluctuate with it. We must learn to regard this as a natural law, and to respect it as we would Newton's first principles. Deputations to Prime Ministers cannot alter it, and socialism cannot cure it. It is not to be changed. Within the last few days a number of very sincere people have written a long letter on boy labour. We agree with every word they say about the injury done to boys by unskilled labour; we should rejoice to see it altered. But we are under no misconception as to the effect of the change upon the volume of occupation. Increasing the intellectual standard will barely affect the demand. We should eat no more if every scullery maid were a competent cook. The business of a country cannot be carried on by intellectuals alone, sheer unadulterated, unadorned, unredeemed labour is an elemental necessity. For every skilled man two or three unskilled are required. All we can hope to

achieve is to give all boys the opportunity of rising; the best will succeed, the worst will join the ranks of casual labour. Peacock expresses the whole matter very pithily through the mouth of Mr. Fax. "It is certainly not enough," he says, "to possess industry and talent; there must be means for exerting them, and in a redundant population these means are often wanting, even to the most skilful and most industrious; but though calamity sometimes seizes those who use their best efforts to avoid her, yet she seldom disappoints the intentions of those who leap headlong into her arms." There is the whole truth; the most we can do is to dissuade boys from jumping headlong into the arms of calamity; we cannot ensure them success, even though we make them amongst the most skilful and industrious.

Engineers in the United States Navy.

SEVERAL years have lapsed since a radical change was made in the *régime* of the United States navy, very largely as a result of the advice given by Admiral Melville when chief of the Bureau of Steam Engineering. Whereas previously engineers were specially educated to be engineers and nothing else, the new system aimed at making every officer in the navy equally competent to fill any and every position. Under this system there was little or no difference in the training which the executive or "military" officer underwent and that which was supposed to produce men fit to take charge of the engine and boiler-rooms of a warship. It will simplify what follows if we say here that the executive, or "military," or "deck" branch of the service is known in the United States navy as "the line." Sufficient time has now passed to enable a good idea to be formed of the success or failure of a scheme which in theory had much to recommend it—so much, indeed, that without following it in all details, our own system of training officers has been modelled on it, with some more or less important differences no doubt. The theory of the advocates of the plan at the other side of the Atlantic was that young Americans had such a love of mechanism and such a contempt for social questions, which, unfortunately, have not yet been dissociated from machinery, that the cadets would rush to the engine-rooms, and the difficulty would be to provide not engineers but line men. At the time it was pointed out, however, that this was extremely doubtful; because, in the first place, deck duties are in every way more pleasant than those of the engine-room, and in the second place that there are no officers in the world who are more ruled by caste than those of the United States navy.

We learn from the annual report to the Secretary of the Navy by Mr. John K. Barton, Chief of the Bureau of Steam Engineering, that the worst anticipations have been fulfilled; and that unless strong measures are taken to compel cadets to take the engineering course, there will soon be no engineers in the United States navy. A good deal is heard about the deficiencies of the British Navy *personnel*, but we are happy to say that so far as manning our engine-rooms is concerned we are incomparably better off than the United States. Mr. Barton says that it is much to be deplored that the important and satisfactory work of the Bureau's school has had to be discontinued "for want of officers to be instructed." Although the number of officers was always too small, it was "infinitely better to instruct these few than none at all." The report then goes on to deal with the various departments which are suffering for lack of engineer officers. Among these come first the navy yards. "In important yards, with numbers of vessels under repair, the head of the department is without a single commissioned assistant." At the shipbuilding yards the conditions are still worse, "not a single young line officer being on duty there in connection with machinery." It is pointed out that the number and variety of materials used in the navy is constantly increasing, rendering the work of inspection and selection daily more onerous. But the number of officer inspectors is continuously and steadily decreasing. Again, in the drawing-offices of the bureau itself the staff is entirely deficient; there are now only two line officers on duty in the place. Mr. Barton holds—and very properly holds—that the best results can only be obtained when the man who is subsequently to be in charge of machinery afloat sees it made on shore. It would be wearisome to go into further detail concerning the shortcomings which Mr. Barton regards with regret and alarm. It is more to the purpose to consider to what the failure of a system so full of promise is due, and the nature of the proposed remedies.

Congress has interfered at various times at the behest of men who, presumably, understood what they were talking about; but from the first there were, as we have said, protests. It was strongly maintained that, no matter what theory might say, it would be found absolutely necessary to keep the two branches—that is to say, the line and the engineers—distinct. As far back as 1899 the then Assistant Secretary to the Navy Board wrote:—"The building of engines, like the building of guns or torpedoes, must be done by special officers selected or detailed for the purpose." After various modifications we come down to 1906, when the "Personnel Board," of which the present Assistant Secretary of the Navy was President, after much consideration, reported:—"The Board, while in favour of the amalgamation of the line and former engineer corps, as provided by the present *personnel* law, in a general sense, desires to express the opinion that experience shows that some specialisation for the design and inspection of machinery should be created." We gather from Mr. Barton's report that the present dearth of engineers is in part at least due to the lack of line officers. The authorities regard engineering of secondary importance, and keep all the young men—nothing loth it would seem—for the deck instead of the engine-room and the workshop. Mr. Barton insists that this practice must be abandoned, and he asks for that to be done which is in effect an abandonment of the essential feature of the scheme. In the hearing before the Naval Committee, the then Assistant Secretary to the Navy said, "My own view is this: That we should, within the department, by detail, directly reverse the policy that has for some time obtained there, of having every man in turn do every duty, the fact that he has performed the duty being considered a reason why he should never perform it again; and, on the contrary, we should, as far as we can, differentiate men after they have passed through the first eight or ten years." Mr. Barton concludes his report with the following words: "It is this differentiation that the bureau earnestly recommends for the consideration of the department. The plan to accomplish this is simple, will cost no money, and requires legislation only so far as to amend the *personnel* Act as follows: Provided, that the provisions of Sec. 5 of the Act of March 3rd, 1899, shall apply to such line officers as may be assigned to permanent engineering duty by the Secretary of the Navy. A number of officers have shown marked aptitude for engineering duty and are now ready and willing to be assigned to engineering duty only, if the opportunity is given them under the above-mentioned conditions. Without such a system, engineering in the navy must fail, and any deficiency there means as much to the efficiency of the fleet as failure in guns or torpedoes."

The truth seems to be that, leaving all social questions on one side, it appears to be physically as well as mentally impossible to collect a body of men who shall be at once eminently fit for the deck and the engine-room. The duties to be performed, the lines of mental occupation, the particular capacities and qualifications required are so different, that it is certain that only a limited number of men can ever rise beyond a very insufficient mediocrity in both positions—that is to say, a good line officer can scarcely be a good marine engineer. It is probably yet more unlikely that a good marine engineer can ever make a thoroughly efficient line officer. There is a great deal to be said in favour of a single education up to a certain point; beyond that it is better that specialisation should take place. The difficulty in the United States seems to be that specialisation in engineering is unpopular both with the men and the Navy Board. Mr. Barton, if he had his way, would compel men to come into the engine-room. Is it not possible that there is a better method? Might it not be possible by some effort to make engineering popular in the United States navy? Or are we to believe that the service as a whole is so unpopular that men are perforce kept out of the engine-room because there are not many enough for the deck? That is the conclusion at which Mr. Barton compels us to arrive.

Marine Condensers.

MR. ROBERT BRUCE was quite right when he told his audience at the Institute of Marine Engineers on Monday, the 16th of November, that the dependence of the steam turbine on a high vacuum for economy was answerable for various developments which had recently taken place in condensing plant. It is well to remember that for many years marine engineers had been quite satisfied if they got a vacuum within two or even three inches of the barometric vacuum. But Mr. Parsons wants a great deal more than that, and has devised very ingenious, albeit costly, methods of obtaining what he requires. With the reciprocating engine very little is to be gained by working on an exceptional vacuum, the back pressure remaining much the same, for instance, whether the vacuum is 25in. or 27in.—not enough, indeed, to compensate for the reduced temperature of the feed water. Mr. Bruce considered surface condensation from various points of view, but he left quite untouched one point—namely, the nature of the process of condensation, or, in other words, the phenomena of the transfer of heat from steam to cold metal or cold water. It is quite clear that the actual refrigerating surface presented to exhaust steam by a jet of cold water is insignificant as compared with that of the metal in a surface condenser. Yet the jet is thoroughly efficient; and it is difficult to explain why a foot of tube surface in a cold surface condenser appears to be altogether less efficient than a similar area inside a hot cylinder.

Mr. Bruce laid stress on the necessity for compelling exhaust steam to flow to every part of a condenser, and referred to the use of baffle plates for this purpose. We have never yet heard, however, of any difference existing in the pressures inside a condenser no matter where they were taken; nor is it at all clear that baffle plates have ever been of use. It seems to be of much importance that the tubes shall be kept as dry as possible, and this is no doubt the reason why the Contraflo condenser is so efficient; but precisely why much water hanging on surface condenser tubes should render them inefficient has yet to be satisfactorily explained. The water cannot be hotter than the metal of the tube, and ought in itself to be a perfect cooling medium, but it is not. After all, however, the efficiency of a surface condenser depends on quite another factor. If results are not quite what we desire, then augment the weight of condensing water, or increase the area of the cooling surface, or do both. But given certain settled conditions, a condenser of a given size, air and circulating pumps of fixed proportions, then the number of inches of vacuum will depend far more on the leakage of air into the condenser than on any other factor. We do not think that this truth is appreciated as it ought to be. In the old low-pressure days the engines derived at least half their power from the vacuum, and they were even more dependent than turbines on it. A small crack that could hardly be seen in a jet condenser would render the working of the engines most unsatisfactory and wasteful. Whether a trip was made up to time or not sometimes depended on the powers of a thick smearing of tallow to keep air out of the condenser. A story is told of an American Monitor, with horizontal engines, which came in for overhaul. When subsequently taken out for trial, a vacuum of about 10in. only could be obtained. Days and even weeks were spent in trying to ascertain the cause. At last a workman passing over the engines kicked aside a mat on the starting platform which happened to be the top of the jet condenser. The engines were under steam at the time. He heard a whistling noise, and found that a small rivet had dropped out, and air was rushing in. The mat prevented the fact being known. He put in a peg of wood, and the engines at once worked up to their proper speed. If it was possible to keep air out of a condenser, there could be no difficulty in maintaining a very high vacuum indeed. The auxiliaries and devices adapted by Mr. Parsons and others are merely appliances for getting air out. If as much ingenuity was expended in preventing it from getting in, the results would be even better, because prevention is better than cure.

Keeping for the moment to the normal triple-expansion engine, let us see where the air gets in. There ought to be no air in the water, which is boiled over and over again. Nor can any leak into the boilers, except when they are cold. But as there is always a minus pressure in the low-pressure cylinder, air will leak into it wherever it can, and most of all, no doubt, round the piston-rod in the stuffing-box. The old Cornish engineer quite well understood the importance of keeping air out, and to that end the piston-rod was surrounded in the stuffing-box with a lantern brass, and this brass was always charged with water, by a pipe and overhead cistern, which effectively kept the air out. A less elaborate device was a large saucer-shaped iron ring forming part of the gland, which, being kept filled with water, prevented air from passing in; but the

water was often blown out during the indoor stroke. It is an unfortunate circumstance that leaks of air into an engine do not show themselves. They have to be searched for with the flame of a candle, and that is by no means an easy task. Again, many condensers leak air, particularly when they are provided with such things as soda cocks and auxiliary feed cocks. Plenty of care is taken that there shall be no steam leaks, but very little attention is paid to air leaks, simply because they are never automatically obvious.

"It is the last straw that breaks the camel's back"—it is the search for the last inch of vacuum that turns the hair of the engineer white. Well may he ask if it is worth the labour spent in getting it. For the reciprocating engine it is not. For the turbine it is absolutely indispensable. Mr. Bruce left nothing unsaid that would direct his hearers in their search for it. When we read about auxiliary condensers, jet air extractors, the entraining of air by water laminæ caused to revolve at a tremendous speed by a small turbine, "augmenters," and other devices named by Mr. Bruce, we begin to think that the modern marine engine-room must be a terrible place as compared with its old-fashioned predecessor. No doubt the numbers of marine engineers who will ask what is the advantage gained by the shipowner in pounds, shillings and pence will not be small. Somebody will, no doubt, be a gainer. It would be interesting to learn who he is and how much.

Industrial Accidents in the United States.

THE Labour Bureau of the United States has just published statistics which are appalling if true. According to these figures, during the year 1907 two millions of workmen were injured, and 35,000 killed while carrying on their trades. Taking the average family at five persons, it would seem that one person in every eight families is injured more or less seriously every year. The report, very truthfully, states that America is behind Europe in safeguarding the lives of workmen; and holds that half the casualties could be avoided by improved factory legislation, inspection, and control. It has long been known that the United States railways are notorious for the reckless disregard of life with which they are managed; but the figures we have given above will come as a revelation to most persons. We can only hope that their accuracy will be disputed. Yet bearing in mind the official statistics of the railways, it is not easy to find much comfort in this hypothesis. It has long been known, indeed, that accidents were numerous; and bitter discussions have raged as to the cause of them and the best way of preventing them. The trades unionists insist that they are very much more numerous in the "open shops" than in those run entirely by union hands. Thus one of the unions recently complained to New York city authorities that large numbers of "house smiths" had been killed during the erection of the Chelsea and Blackwell's Island—Queenborough—bridge piers, which were constructed by both union and non-union men. The complainants asserted that fifteen men were killed on the Chelsea and fifty-five on the Blackwell's Island pier work. In reply to this assertion, Commissioner Walter Drew, of the National Erectors' Association and the Allied Iron Association, says that three deaths only occurred in the course of the erection of the Chelsea piers, that only thirteen men were killed during the work on the Blackwell's Island Bridge, and that three of the men killed were old union men of long experience, who were working on the open shop plan. He adds that the proportion of men killed during the erection of the Blackwell's Island Bridge was one for every 4000 tons of iron erected, while during the work on the Williamsburg Bridge, a strictly union contract, one man was killed for every 1340 tons erected.

The point raised is one of considerable interest. In the first place, how far is lack of personal skill and practical experience responsible for so-called accidents? and, in the second place, is or is not a trades unionist better off in these respects than a non-unionist? A further question might be, how far inebriety affects the numbers of those killed or injured, and, admitting that it is a factor, can it be shown that the unionist is steadier than the non-union workman? In this country, it has been stated, and not very forcibly or convincingly contradicted, that since the Workmen's Compensation Act came into force employers have dismissed men because of their age, as they no longer considered them "safe." To which it has been replied that it is the older and more experienced men who escape injuries, and that it is the young, rash, inexperienced hands who suffer. Some years will, perhaps, pass before the point is settled. It is a significant fact, however, that the insurance companies have announced their intention of raising the premiums on risks in some trades. As for the loss of life in the United States, it seems to be quite clear that there are special causes at work which can only be controlled by some very strong expression of public opinion, which is not very likely to take place; or by drastic changes in the law, which probably could not be enforced. It is indisputable that the people of the United States do not attach anything like the value to life that we do in the Old Country. They seem to stand half way between the Chinaman and the European. In the matter of scaffolding, for example, whether on bridges or high buildings, it is extremely difficult to get the workmen to take proper precautions for their own safety. Sometimes this is attributed to a "policy of hustle." It is doubtful, however, whether this hustling does not exist more in name than in fact. The reckless disregard of human life lies in causes below the surface. Climate has no doubt much to do with it. Judged by our standard it is deplorable; but every nation has its own standard, and by that it expects to be judged.

The Legality of Railway Agreements.

ELSEWHERE in this issue it is stated that the agreement between the London and North-Western Railway and the North London Railway that the former company shall work the line of the latter is to be submitted to the Railway and Canal Commission for approval. It is also now generally known that parliamentary sanction is being obtained for the agreement between the Great Northern, Great Central, and Great Eastern Companies; also for that between the Taff Vale, Rhymney, and Cardiff Companies. On the other hand, the new relations between the London and North-Western and Midland Companies, and those between the Scotch Companies, far-reaching as they are and closely affecting the public, have not been sanctioned by either Parliament or the Railway and Canal Commission, nor is it intended that they shall be submitted to either of these bodies. This difference of treatment may appear strange, but it can readily be explained. As related in our notice as to the North London Railway, parliamentary sanction for the proposed arrangements was obtained in 1861, but was conditional on the approval of the Board of Trade, whose powers in such matters were transferred to the Railway Commission when that body was created in 1873. The triple agreement has to be sanctioned by Parliament, as the undertakings are to be combined, and it will be necessary for the Joint Committee to be a legalised corporation, the powers possessed by the Rhymney Company and the Cardiff Railway and Docks must also be legally transferred to the Taff Vale Company. To do this parliamentary sanction is the only way. Confusion rests in some minds because in the Railway Clauses Act, 1863, Part III. refers to working agreements, and this provides that any agreements as to the maintenance and management of railways, their use and working, and the apportionment of tolls, shall not be effective until sanctioned by the Board of Trade—now by the Railway Commission—but it is generally overlooked that the clauses open by remarking: "Where two or more companies are authorised by a special Act hereafter passed." In an article on the "Relations between Railways and the State" in THE ENGINEER, of June 12th last, we drew attention to this, and observed, "It does not therefore apply to any agreement for which powers are not obtained, such as pooling traffic." Our view has since received confirmation in the highest quarter. In the House of Commons on November 4th a question was asked that covered agreements as to working traffic, pooling receipts, abolishing intercompetition, and establishing a community of interests. To this the President of the Board of Trade replied, "The Railway and Canal Commission only have power to review such agreements as are entered into under the authority of special Acts of Parliament incorporating Part III. of the Railway Clauses Act, 1863. . . . It hardly appears necessary to consult the law officers of the Crown on this point, which I am advised is not open to doubt."

Steel Castings.

IS it true that commercial steel castings are not obtainable in Great Britain under reasonable conditions of price, delivery, and soundness? We hear such diverse opinions that we put the question to those of our readers who have endeavoured, either with or without success, to obtain sound castings in this country. That magnificent castings are made here cannot for a moment be doubted, every one of our battleships is full of them. That they can be made for the ordinary market in competition with German castings we also believe, but there is much difference of opinion about the matter. Only within the last few days we have been told by two separate and independent engineers that they failed to get sound castings in England, but got them with ease in Germany, and the quality of the metal was superior in every way, whilst the finish was excellent. On the other hand, we have been told by purchasers that they had no difficulty in obtaining what they wanted in any quantity, and, needless to say, there are many steel makers who ridicule the idea that German castings are better than British. Where does the truth lie? It is very important that it should be known one way or the other.

LITERATURE

Aërodonetics. Constituting the second volume of a complete work on Aërial Flight. By F. W. Lanchester. London: Archibald Constable and Co., Limited.

MR. LANCHESTER, whose work in motor engineering is well known, and whose qualifications to undertake such a task are beyond question, has in the present volume completed a comprehensive treatise on the science of flight. His first real acquaintance with the subject began in 1894, when, in experimenting with small models, he was successful in producing some whose flight was remarkably stable. From then until the present time his work has been devoted to the determination of the underlying principles; experiment and theory have advanced together, and he has attempted, and with some degree of success, to lift the subject from the level of mere empiricism to that of an exact science. Still, for all the author's aspirations, the size and scope of the present work far exceeded his expectations. When the results of experiments were first collected for publication, gaps were found, and further investigations were conducted. These, though delaying the appearance of the book, added considerably to its value, and the author finally decided that it should take the form, not of a mere record of experimental results, but of a comprehensive treatise.

The first volume, it will be remembered, was entitled "Aërodynamics," and was published some months ago. It treated generally of the resistance offered, and the support given by a medium to a body in motion through it. The necessary amount of fluid dynamics was briefly treated, and the present experimental and theoretical knowledge of the aëroplane was discussed at some length. The second and completing volume deals with the complete motion of a body in free flight.

The author is a close student of natural phenomena bearing upon the subject; but whilst he recognises the importance of a close observation of bird flight, he also realises the difficulty of applying the results. The stability of a gliding bird is a problem presenting difficulties; the ratio of the two elements, automatic action and nervous control, is as yet indeterminate, and while so, observed results cannot be applied with confidence. The opening chapter of this volume is devoted to a brief study of the motion of the simple aëroplane. From a pure qualitative point of view, the path of flight, and the lateral, longitudinal, and directional stabilities are briefly discussed. Descriptions of some interesting early flying models are given, and also an account of a short set of experiments carried out by the author on a simple aërodone. These are amply discussed, and in one or two cases diagrams of the estimated flight paths are given. These are somewhat interesting. The Phugoid theory is treated in succeeding chapters. This theory, dealing with the form of the flight path, and the longitudinal stability of an aërodone, is discussed from an analytical point of view. The equations are reduced to a convenient form for plotting, and a Phugoid chart, for various values of the constants, is included. The deductions from the theory are of considerable importance. An important chapter follows, in which the results of experiments, confirming the Phugoid theory, are given at some length. The results are not always of the most convincing, and further experimental work on this subject would be of value. The lateral and directional stabilities form the subject of a long and valuable chapter. One of the most interesting sections in the book is devoted to that most puzzling mode of flight, soaring. The word, as it is here applied, is intended to represent that motion, of which many of the heavier birds are capable, at an approximately uniform level for indefinite periods. Gulls have been known to cross the Atlantic without using their wings for propulsion. The two most important theories, attempting to account for the observed facts, are dealt with at some length. The upward air current theory receives some support from the fact that birds are able to avail themselves of an upward air current caused by a natural obstacle such as a cliff. The theory accounting for a bird's apparent immunity from gravitational influence on the supposition that it is able to extract energy from wind pulsations will, however, appeal more to most readers. A description of an interesting model illustrating this theory is given. Curiously enough, this model, which was invented by Bazin in 1890, was by a coincidence re-invented by the author a few years later, in almost identical form. Considerable work has been done in connection with this theory, and will be found in detail. A section on experimental aërodonetics brings the book proper to a close.

A few appendices, which might almost have been

introduced into the text, conclude the book. The gyroscope, the drift of a projectile, and the flight of a boomerang are to the scientific reader ever new subjects, and the author has dealt simply but effectively with them.

A section which will appeal to readers who desire to take up experimental work is that which deals with the actual construction of soaring models. Mr. Lanchester has made large numbers of these—from tiny things weighing but a few grains up to larger planes weighing many ounces—out of talc, and he gives valuable hints as to the management of that material.

The work, though it includes analytical investigations of the more important problems, is written on generally non-mathematical lines. The mathematical treatment is given as an adjunct to the general statement, and the simpler cases are treated first. This method is desirable for the student. It enables him to understand the simpler problems, not as particular cases of generalisations, but as problems capable of direct solution even if his mathematics will not carry him through the more difficult solutions.

SHORT NOTICES.

Elementary Dynamo Design. By W. Benison Hird. London: Cassell and Co., Limited, La Belle Sauvage, E.C. 7s. 6d. net.—There are now many excellent books on the subject of dynamo design, but the majority of them are more suitable for readers who already have some knowledge of the subject than otherwise. Controversial points as to the nicety of design are considered in many of the standard works which are of more interest to the real designer than those who desire to gain an elementary knowledge. The present volume appears to us to fill a long-felt want, for as its title implies it is strictly elementary. A knowledge of the theory of electricity is, of course, assumed, but at the same time introductory chapters deal with theoretical points that are most intimately connected with dynamo design. The book is divided into ten chapters, which, among other things, deal with various types of dynamos and motors, the continuous current generator, the continuous current motor, mechanical details, continuous current dynamos and motors for special purposes, alternating currents, the three-phase generator, the three-phase induction motor, and other varieties of alternating current motors. Calculations are gone into for designing various kinds of alternating and continuous current machines, and these numerical examples serve to give the reader a good elementary knowledge of the subject with which the book deals.

Steam Power Plant Engineering. By G. F. Gebhardt. London: Chapman and Hall, Limited, Henrietta-street. Price 25s. net.—This is an American book which deals almost exclusively with American practice and ideas. The subject is one which would require many volumes as large as the one before us to do it justice. It is intended for advanced technical students, who will, we believe, find it valuable, besides interesting. Dealing so generally with the subject, it has only been possible to give the "essentials" of power plants, but it is in the descriptions of the arrangement and combination of the various units of the plant that the real value of the book lies. Particularly good engravings are given with the sections of the book devoted to steam boilers, engines and condensers. Other very useful information given includes typical specification of engines, boilers, condensing plants and for purchasing coal, &c.; also A.S.M.E. rules for conducting steam engine and boiler tests. The treatment of the subject, together with the many tables, curves, diagrams, and other information of a practical and useful nature, tend to make this book more than a mere college primer. It is well written, and the illustrations throughout are exceptionally clear.

The Principles and Practice of Surveying. Vol. II.: Higher Surveying. By Charles B. Breed and George L. Hosmer. London: Chapman and Hall, Limited, Henrietta-street, Strand, W.C. Price 10s. 6d. net.—This book is issued in two volumes. The first dealt with elementary surveying, and included chapters on the use, adjustment, and care of instruments, surveying, computations, plotting, finishing, and filing surveys, &c. In this volume the authors divide the subject into four parts—namely, the control of the survey, filling in topographic details, hydrographic surveying and stream gauging, and constructing and finishing maps. In Part II. the methods of making topographic surveys are considered, including the stadia, plane table, and photographic methods. In the chapter on the plane table an attempt has been made to show that this method has advantages which the authors claim are not sufficiently appreciated by many surveyors. The chapter on hydrographic surveying treats of the usual methods of conducting harbour and river surveys.

Heat for Engineers. By Chas. R. Darling. London: E. and F. N. Spon, Limited, 57, Haymarket. Price 12s. 6d. net.—There are now many books on the subject of heat, but few attempts have been made to provide a book which appeals to the engineer. The majority of books on the subject are written for students preparing for examination in the theory of heat, and, as the author states, such subjects as refrigerating machinery, ice machinery, cold storage, fuels, and pyrometry, although of great commercial importance, seldom receive more than the briefest mention in ordinary treatises. The object of the present volume is to deal with the numerous applications of heat in modern industrial processes, and to furnish information and data requisite for a correct understanding of the thermal phenomena involved. The book appears to fill a long-felt want, for it contains that information which engineers most require to know.

The American Machinist Handbook. By F. H. Colvin and T. A. Stanley. London: Hill Publishing Company, Limited, 6, Bouverie-street, E.C. Price 12s. 6d. net.—This book presents in convenient form data which should prove of value to practical men engaged in the various branches of machine work. It contains information pertaining to cutting screw threads, standard proportions of screw threads, measuring screw threads, pipe and pipe threads, twist drills and taps, files, soldering, gearing, milling and milling cutters, grinding wheels and grinding, punch press tools, and so forth. The book contains nearly 500 pages of reading matter and illustrations, and it is well indexed. The directory section should be found of service to the younger mechanics and should help to establish standard names for various parts, which are now more or less confused in different sections of the country.

Highway Engineering. By Charles E. Morrison, A.M.C.E. New York: John Wiley and Sons. London: Chapman and Hall, Limited. 10s. 6d. net.—This book was originally written for the second-year students of the Department of Civil Engineering at Columbia University, with a view to furnishing a text in which the fundamentals of the subject should not be buried in a mass of detail. The book, therefore, is not a reference work, but one which is intended to outline and emphasise those basic principles which are essential to good highways. There are ten chapters, which deal with road resistances, earth roads, gravel roads, broken stone roads, miscellaneous roads, street design, stone pavements, brick pavements, asphalt pavements, and modern wooden pavements.

Road Preservation and Dust Prevention. By William Pierson Judson, M. Inst. C.E. London: Archibald Constable and Co., Limited. Price 6s. net.—The enormous increase in road locomotion during the past few years has rendered the subject of road construction one of much importance. The present volume is a small book which deals with treatment of roads with oils and tar. Several processes and machines are described, and where possible the working costs are given. The data have been culled from various reliable sources, and should prove of value to road surveyors. It is an American book, and throughout the prices are given in dollars, &c.

BOOKS RECEIVED.

Die Portland-Zement Fabrikation. By Carl Thomas. Leipzig: Theod. Thomas. Price 17 marks.

University College Calendar: Session 1908-1909. London: Taylor and Francis, Red Lion-court, Fleet-street, E.C.

The Temperature-Entropy Diagram. By C. W. Berry. Second edition. London: Chapman and Hall, Limited. Price 8s. 6d. net.

A Digest of Railway Accounts. By A. C. Anderson. London: Gee and Co., 34, Moorgate-street, E.C. Price 3s. 6d. net.

Les Flottes de Combat en 1909. By Commandant de Balincourt. Paris: Berger Levrault et Cie., 5-7, Rue des Beaux-Arts. Price 5f.

The Design and Construction of Ships. Vol. I. By J. H. Biles, LL.D. London: C. Griffin and Co., Limited, Exeter-street. Price 25s. net.

The Daily Mail Year-book for 1909. Ninth year of issue. London: The Amalgamated Press, Limited, 26-29, Bouverie-street, E.C. Price 6d. net.

The Mechanical Engineering of Steam-power Plants. By F. R. Hutton, D. Sc. Third edition. London: Chapman and Hall, Limited. Price 21s. net.

Annuaire pour l'An, 1909. Publié par le Bureau des Longitudes. Paris: Gauthier Villars, Quai des Grands Augustins 55. Price 1f. 50 c.

The Business Prospects Year-book, 1909. By J. Davies and C. P. Hailey. Cardiff: Business Statistics Publishing Company, 12, James-street. Price 5s.

The City Diary, 1909. Forty-sixth year of publication. London: W. H. and L. Collingridge, *City Press* Office, 148 and 149, Aldersgate-street, E.C. Price 1s.

The Essentials of Descriptive Geometry. By George H. Follows. London: The Hill Publishing Company, Limited, 6, Bouverie-street, E.C. Price 8s. 6d. net.

Directory of Manufacturers on the North-Eastern Railway System. By H. D. Dryden, Chief Goods Manager. York: Commercial Agency, North Eastern Railway. Gratuitous.

The Care of the Car and How to Drive it. Edited by Lord Montagu of Beaulieu and R. J. Mecredy. London: *The Car Illustrated,* Limited, 168, Piccadilly, W. Price 1s. net.

Alternating Currents Simply Explained. By A. W. Marshall, M. Inst. Mech. E. London: Percival Marshall and Co., 26-29, Poppins-court, Fleet-street, E.C. Price 6s. net.

Machine Drawing and Design for Beginners. By Henry J. Spooner, M.I. Mech. E., Assoc. M. Inst. C.E. London: Longmans, Green and Co., 39, Paternoster-row, E.C. Price 3s. 6d.

Elementary Manual of Steam and the Steam Engine. By Prof. A. Jamieson, M. Inst. C.E. Twelfth edition. London: C. Griffin and Co., Limited, Exeter-street, Strand, W.C. Price 3s. 6d.

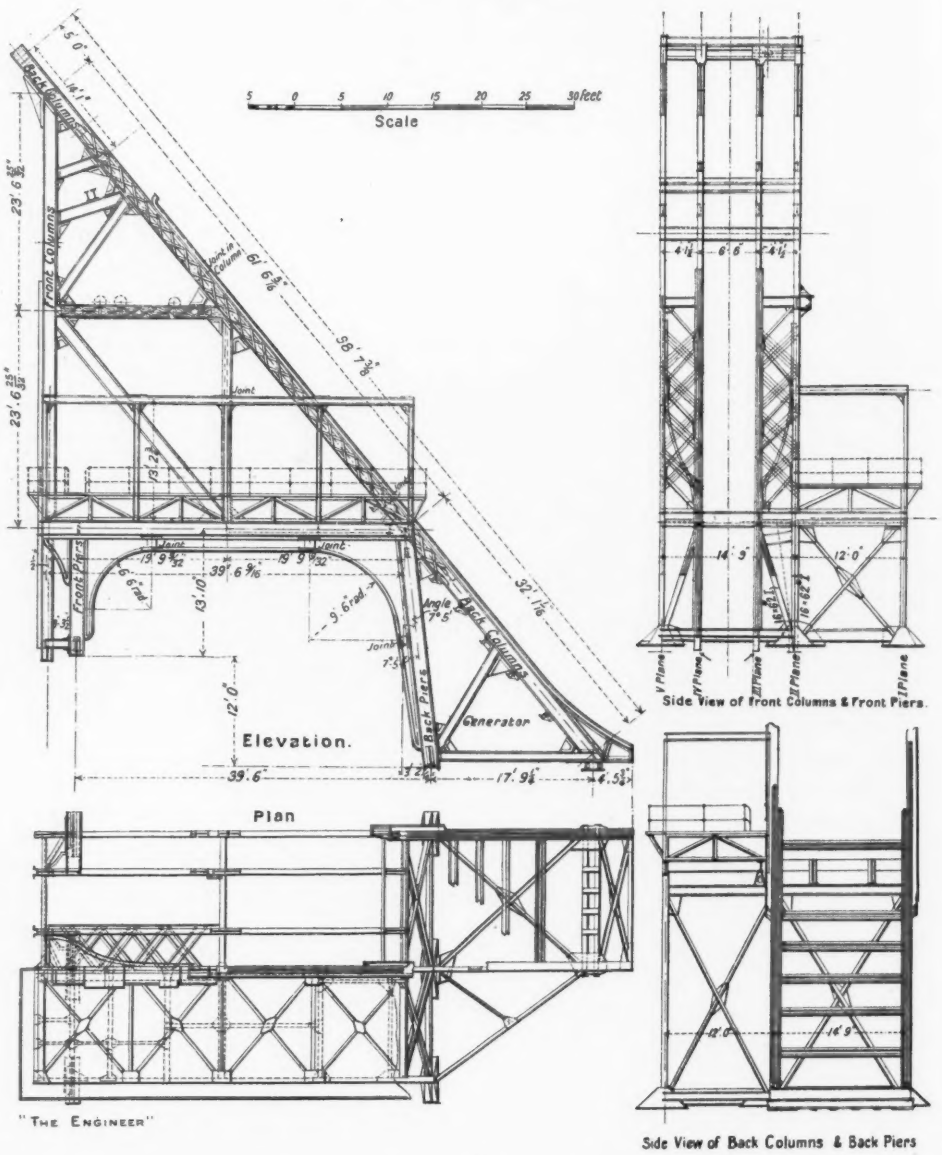
The Modern Practice of Coal Mining. By Daniel Burns and George L. Kerr. Part III.—Sinking and Fitting Shafts. London: Whittaker and Co., 2, White Hart-street, Paternoster-square, E.C. Price 2s. net.

The Guide to South Africa. 1908-9 edition. Edited annually by A. S. and G. G. Brown, for the Union-Castle Mail Steamship Company, Limited. London: Sampson, Low, Marston and Co., Limited. Price 2s. 6d.

Tutonish: An International Union Language under a Liberal Anglo-Saxon Leadership. By Elias Molee, Ph.B. London: Kegan Paul, Trench, Trubner and Co., Limited, Dryden House, Gerrard-street, W. Price 1s. net.

DETAILS OF COAL SHIPPING PLANT

(For description see page 651)



"THE ENGINEER"

COAL SHIPPING PLANT FOR JAPAN

HEAD, WRIGHTSON AND CO., LIMITED, THORNABY-ON-TEES, ENGINEERS

COAL SHIPPING MACHINERY FOR JAPAN.

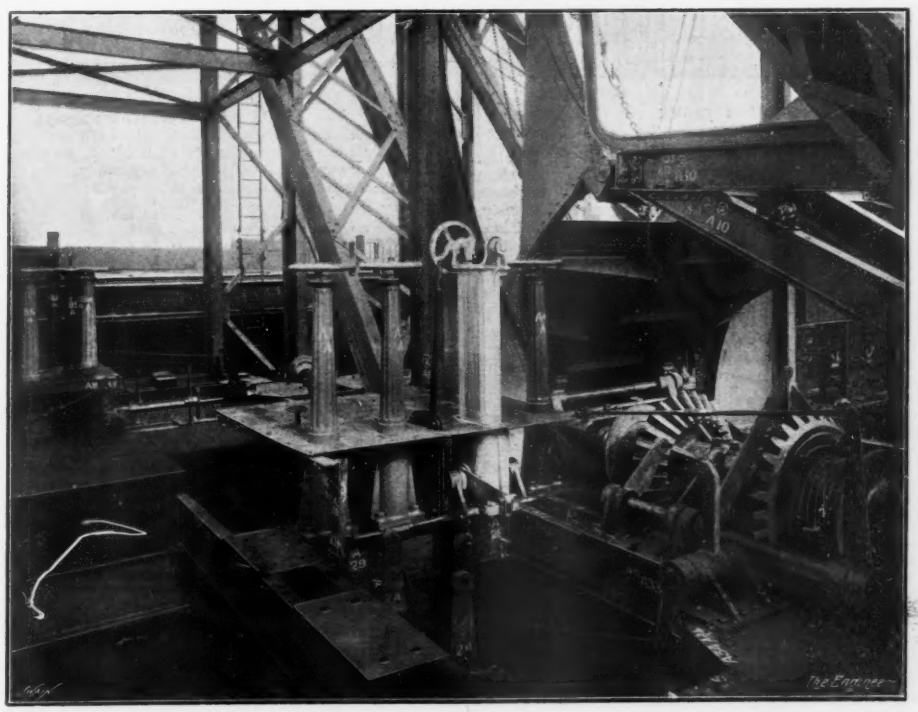
THE engravings given herewith and on pages 646 and 650 illustrate two rapid skip coal loaders which have recently been constructed by Head, Wrightson and Company, Limited, of Thornaby-on-Tees, for Messrs. Mitsui and Company, of Japan, and to the joint designs of Messrs. Takuma Dan, director, and Tsumena Kuroda, engineer, of the Mitsui Mining Company, and under the inspection of Mr. M. Hino, engineer, the Miike coal mines of Japan. The structure consists of two main frames 13ft. 9in. centres and 72ft. high from the front rails to the top, the back rails being 12ft. lower. The inclined members, 50 deg. to the horizontal, have secured to them rails for the travelling skip. There are two vertical members, 6ft. 6in. centres at the front, which serve as guides for shoots to travel upon, and also a further frame which extends only to the first floor level, where the engine-house is situated. The whole is carried on six sets of travelling wheels—four to a set—of which two only have power transmitted to them, the other four sets acting as followers, whilst the tail end is carried on two smaller travelling wheels.

The structure has been designed to admit of the passage on the wharf level of two locomotives on separate sets of lines under the portals. At intervals of 20ft. along the wharf at Miike Harbour there are recesses in which inclined rails are so laid that in the event of the loader being stopped at a position opposite a jacket the incline of the rails is continued on the loader. Above these rails, in each recess, is fixed a hopper or shoot into which coal is delivered from trucks on the main lines. From this hopper the coal is dumped into the skip, which is then hauled up the incline by means of a wire rope over the main winding pulley at the top of the structure to the height required for tipping. On each incline there are two rails, the outside rails being 14ft. 9in. centres and extending to the highest positions required for tipping, and the inside rails, 13ft. 10½in. centres, extending only to the engine-house floor level. Between these latter is a further pair of rails, 13ft. 1in. centres, termed the telescopic rails, fixed to a braced framing which may be hauled up by means of a wire rope to any required height. Towards the top of this framing the rails leave the plane of the incline as they are bent round to nearly a horizontal plane towards the front of the loader, and their extreme ends are turned so as to form stops for the front wheels of the travelling skip. This skip is composed of steel plates, &c., mounted on two pairs of wheels and with two buffers at the rear, and has a capacity of eight tons. The rear wheels are fixed to run only on the outside rails, 14ft. 9in. centres. The front wheels, fixed midway between the front and rear wheels, are of the double-tread type, so as to take both the outside fixed rails, 13ft. 10½in. centres, on the incline, and also the movable telescopic rails, 13ft. 1in. centres.

The following is the method of tipping:—After being charged with coal, the skip is hauled up the incline from the recess, the front wheels travelling on the two outside fixed rails until the skip reaches the engine-house floor level. Just previous to reaching this point, the front wheels of the skip take the telescopic rails, and, continuing on these alone up the incline, they follow the line of the aforementioned bent rails until reaching the stops. The rear wheels travel the entire distance on the outside fixed rails. The skip, upon reaching this point, is then at right angles to the incline, and therefore tips its contents into the shoots. Each loader is fitted with four shoots. The first shoot is connected to the top end of the telescopic rails, and is provided with rollers on each side running on a path fixed to a member parallel to the incline.

The second shoot is hinged to the lower end of the first shoot, and has at its lower end at each side a roller running on an angle iron track on the top edges of the third shoot. The upper end of this third shoot is hinged to a movable clamp, which travels up and down the front vertical members, and may be securely fixed to these at any required position. The lower end of this shoot is hung by means of a wire rope. The fourth shoot, provided in order to allow for the distribution of coal in the vessel, is fitted with rollers to run on the outside of the third shoot, and it is raised and lowered by means of bevel gear and screw worked by a hand chain from the deck of the ship. The following is the method of raising the shoot:—The lower end of the second shoot is raised to any convenient height by means of a wire rope. Then the telescopic rail of the first shoot and the upper end of the second shoot and also the upper end of the third shoot are raised simultaneously by means of wire ropes from drums on one shaft to their respective paths previously described, until the lower end of the second shoot rests on the third shoot. The lower end of the third shoot is then raised, in order to complete the incline of the shoot, and, finally, the fourth shoot is adjusted as may be necessary. The drums on the shaft used for hauling the telescopic rail, &c., have their diameters arranged so as to allow for the clamps travelling in a vertical plane at a relative speed to the telescopic rail on the inclined plane. At the top working position of the shoots the second will be telescoped into the third shoot. To permit of the loader clearing the rigging, &c. on the skip when travelling along the wharf it is possible to raise the second, third, and fourth shoots to an upright position, the shoots then having a range of 30ft. between the highest and lowest working positions.

Situated on the floor, immediately above the portals, are two electric motors, the larger one being used for hauling the skip and for moving the loader along the wharf, whilst the smaller one is used only for raising and lowering the shoots. Alternating current of 2200 volts, transformed by a motor generator on each coal loader to direct current, 550 volts, is used. The electrical equipment was supplied by the British Thomson-Houston Company. The various drums for hoisting the skip and shoots are provided with coil clutches and powerful foot and hand brakes, whilst limit switches are also provided to obviate over-winding. The two coal loaders are to be erected alongside a dock wall at Miike Harbour, and they will each have a working capacity of 500 tons of coal per hour.



MACHINERY PLATFORM OF COAL SHIPPING PLANT

THE NORTH LONDON RAILWAY.

WHEN discussing the railway position in THE ENGINEER for August 21st last we observed, "The North London has fallen from its high state of paying 7½ per cent. for many years to only paying 3½ per cent. Anonymous circulars have been issued suggesting that the London and North-Western take the line over and guarantee the shareholders 5 per cent. This is most unlikely, but there seems no reason why the North-Western should not work the line and so reduce some of the administrative charges." A fortnight ago a notice was issued to the proprietors of the London and North-Western Railway to attend a meeting to consider, and, if thought fit, to approve an agreement with the North London Railway in accordance with the North London Railway (City Branch) Act, 1861. From a subsequent notice it appears that certain of the officers of the North London Railway are to be dispensed with, the line is to be worked as a division of the North-Western, and the latter company is to supply rolling-stock, engine power, material, &c. The new conditions are to come into force as from January 1st next, and to remain in operation for twenty-one years unless the North London thinks fit to terminate them earlier. This, it is proposed, it may do at any time after the first twelve months, on giving six months' notice. The meeting of the North-Western proprietors was being held yesterday as we went to press. If they approve the agreement only requires the sanction of the Railway and Canal Commission.

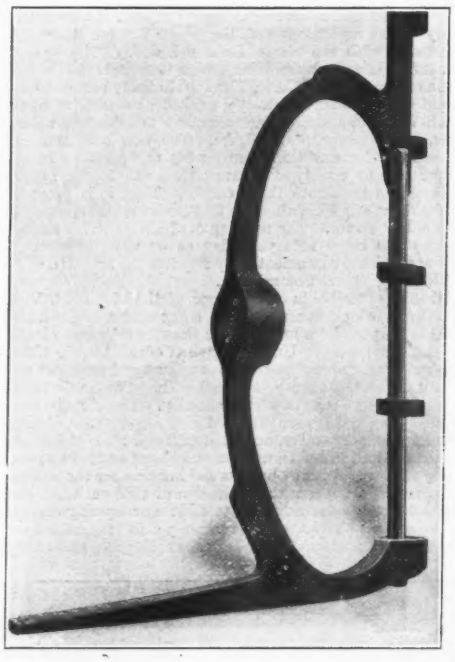
All this is possible in consequence of the Act (24-5 Vict., ch. cxcvi.), which sanctioned the construction of the Broad-street terminus and a branch from the Chalk Farm to Poplar line near Kingsland. Under Section 47 of the Act, the North-Western Company had powers to construct and maintain such part of the station as may be agreed. This refers to the Broad-street goods terminus of that company. The Act contains some clauses that were unusual in those days. Clause 45 orders workmen's trains, and Clause 43 says: "If the railway by this Act authorised be not completed and opened for public traffic within the period by this Act allowed for the completion thereof, then from the expiration of that period it shall not be lawful for the company to declare or pay any dividend on the ordinary capital of the company until the railway by this Act authorised shall be completed and opened for public traffic." This clause was, without doubt, inserted as a consequence of the large number of lines that were sanctioned and not commenced, so blocking other schemes. Before the Caldwell Select Committee of 1852 3 it was stated that there were then 2000 miles of railway sanctioned, involving 40 million pounds of capital, which had been abandoned without the consent of Parliament, and the Select Committee recommended that when an existing railway had powers to construct a line and did not complete it within a certain time the pay-

ment of any dividends on the ordinary or unguaranteed stock should be suspended until such line had been completed and opened for traffic—see "Relations between Railways and the State," THE ENGINEER, June 12th, 1908. It may be added that the estimated cost was £700,000, and the line was to be completed within five years.

Clause 52 authorised the two companies—the North London and the London and North-Western—to make agreements as to, *inter alia*, the maintenance, management, use and working by both or either companies of all or any part of the North London Railway, and the supply, maintenance, and use of any rolling or working stock and plant required for such purposes, and the employment, payment, and dismissal of officers and servants. Clause 53 says that the agreement must be approved by the Board of Trade and—Clause 54—by three-fifths of the shareholders. Under Clause 55 the Board of Trade are empowered at the end of ten years and of each subsequent ten years to call upon the parties to modify any of the terms. It should be remembered that under Section 10 of the Regulation of Railways Act, 1873, all the powers and duties of the Board of Trade as to working agreements were transferred to the Railway and Canal Commission. As a consequence, the agreement having been already sanctioned by Parliament, if it is now approved by the shareholders, it only requires the sanction of the Commission to become legal. It may be added, in conclusion, that the North-Western have £1,328,000 invested in the North London, practically two-thirds of the stock.

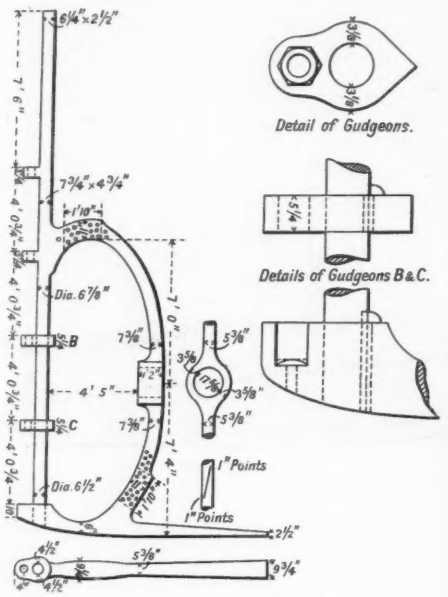
A NEW TYPE OF STERN FRAME.

A NEW type of stern frame has just recently been built from the designs of Mr. Arthur A. Fownes, the managing director of the Fownes Forge and Engineering



STERN FRAME

Company, Limited, of St. Bede Works, South Shields. The peculiarity of the design lies in the fact that the stern frame is built together and is without a weld throughout. The frame is forged in three separate pieces, namely, the back post, the boss piece, and the bottom piece. There



DETAILS OF STERN FRAME

is a scarf joint below the boss and above at the archway, instead of the ordinary weld, whilst the back post is turned circular from immediately below the arch down to the base. Instead of any welding, the post is shrunk into the bottom keel piece. The gudgeons are also portable, and they are shrunk on to the circular back post and keyed in addition. These innovations have been introduced so that the entire frame may be the more expeditiously manufactured. Under this system, the various parts—in course of manufacture—may be distributed over the several machines, and continuity of machine work is thereby maintained until such time as the various pieces are ready for finally fitting together. It is also claimed that rapid repairs are greatly facilitated, inasmuch as a new bottom piece or back post may be provided without the necessity of having to cut out the entire stern frame from the vessel, and similarly, as the portable gudgeons if damaged can be conveniently replaced without the back post having to be condemned as is the case with stern frames of other design. In the Fownes design there has been introduced the method of shrinkage in substitution for the older method of welding, which is slower, as only one set of men can be working on any particular job at the same time. This design of stern frame, we understand, has received the approval of all the various classification societies.

COAL GAS LIGHTING IN RAILWAY CARRIAGES.

FOR some little time now Mr. R. Guest, the locomotive Superintendent of the Isle of Wight Central Railway, has been experimenting with the use of coal gas for lighting railway carriages. The main idea of the scheme has been to utilise coal gas under compression as the illuminating medium, and thus save the initial cost of laying down an oil gas producing plant. The gas used has been drawn from the mains of the local gas company at Newport, Isle of Wight, and has been paid for at the rate of 3s. 10d. per 1000 cubic feet. It has been compressed into a series of five storage cylinders each 9ft. by 20in. diameter, to a pressure of 150 lb. on the square inch. The compression has been effected by two Westinghouse pumps, the first having cylinders, both air and steam, 6in. in diameter and a 9in. stroke. The partially compressed gas is then taken to a second pump with a 6in. diameter steam cylinder and a 3½in. air cylinder by 9in. stroke. In this it is finally compressed. Steam is obtained at 60 lb. per square inch pressure from a locomotive boiler, which also supplies steam for the railway workshop engine.

Newport being the common nightly centre for all coaching stock, it is not necessary to have travelling storage tanks, for the coaches are charged in the sidings adjoining the workshop by flexible pipe in the usual manner. The maximum pressure in the carriage cylinders is 105 lb. on the square inch. Ordinary regulators, gas fittings, &c., are used throughout, and small upright mantles and burners, supplied by the London Lamp Works Company, are employed. The pressure of gas at the burners which has been found most satisfactory is from 1½in. to 2in. of water. The candle-power of each burner is 25, and the light given, although, we understand, not quite so brilliant as that from incandescent oil gas, is eminently satisfactory, and stronger than that given by oil gas flat flame burners.

Mr. Guest has courteously supplied us with the following table, which shows the result of a test carried out during sixteen days with four coaches running continuously :—

Test from November 7th to November 22nd, 1908, both dates inclusive.—No. of Coaches fitted, 4.

I.W. Central Railway numbers	7	9	11	12	
Number of burners respectively	7	5	4	3	Total, 19 lights.
Number of gas cylinders	2	1	1	1	
Sizes of gas cylinders	9ft. × 20in outside & 6ft. 4in. × 20in. outside	9ft. × 20in.	9ft. × 20in.	6ft. 6in. × 22in.	All outside dimensions. Plates ⅜in. thick
Number of times charged	7	9	9	9	
Average pressure in cylinders before charging	Nil	Nil	30 lb. sq. in.	65 lb. sq. in.	
Pressure fully charged	105 lb. sq. in.	105 lb. sq. in.	105 lb. sq. in.	105 lb. sq. in.	

No. 7 coach is fitted with bye-passes. Nos. 9, 11, and 12 are lit each night. Nos. 11 and 12 coaches have always had a certain amount of gas in them when brought in to be charged, owing to their having less burners than No. 9, with which vehicle they always work. No. 7 runs separately.

Number of mantles renewed between the 19 burners	4
Price	6d. each
Total mileage per coach (approximate)	2350
Average hours burning per night	4.5
Total amount of gas consumed	3200 cubic feet
Cost of gas	3s. 10d. per 1000 cubic feet
Consumption per burner per hour	1.63 " "

Mr. Guest, remarking on the experiment, informs us that it has been in every way satisfactory. The only doubtful item at present is the cost of mantle renewals. The tests have not been carried out for a sufficient length of time to indicate reliably what the renewal figures under this head will be. So far there have been four renewals in 178,600 burner miles, or one renewal in 44,650 burner miles; but, of course, this could not be regarded as a reliable average taken over long periods. It would be interesting to know how these figures compare with the costs of other systems of lighting with incandescent mantles in railway coaches.

AMERICAN ENGINEERING NEWS.

A walking crane for shops.—Various types of cranes are used on railway and other works to meet various requirements in handling material. One type is known as the "walking" crane, and is usually a jib crane travelling upon a line of rails on the floor. An electric walking crane has been installed at the Barnside works of the Illinois Central Railway for the purpose of handling wheels and axles in the locomotive erecting and repair shop. It travels between the engine erecting pits and a row of wheel lathes, so that with its revolving jib it can transfer a pair of wheels from a pit to a lathe or *vice versâ*. The crane is of steel construction and consists of a triangular base, on which is mounted the mast, with a horizontal jib braced by a strut from the foot of the mast. Upon the jib travels a hoisting trolley. The crane has two grooved wheels—one at each end of the triangular frame—running on a single rail laid in the floor. It is held in vertical position by horizontal guide wheels or rollers which are carried by a frame rising above the mast and which ride against the flanges of a rolled steel joist laid with its web in a horizontal position. The operating machinery is mounted mainly in the triangular base frame. A 15 horse-power electric motor gives a hoisting speed of 16ft. per minute, and a 10 horse-power motor gives a travelling speed of 180ft. per minute. There are also two motors of 2 horse-power each. One of these is to effect the travel of the hoisting trolley to-and-fro upon the jib. The other is to revolve the mast and jib. The operations are controlled by electrical and mechanical brakes. The crane has a hoisting capacity of 7 tons, a vertical hoist of 10ft., and a working radius of 12ft. It was built by the Whiting Foundry and Equipment Company, of Chicago.

A rotary petrol engine.—Something new in small engines is a petrol engine, which revolves around a stationary shaft, the power being taken from a wheel bolted to the revolving cylinders. The shaft is horizontal, and the five cylinders radiate from it in a vertical plane. The ends are bolted to a casing or sleeve, which also has a circular muffling chamber having the appearance of a fly-wheel. The cylinders are cooled by air, but much more effectively than in the usual arrangement of air-cooled engines. The revolving or rotating cylinders perform in themselves the function of a fly-wheel. The charges, also, are exploded alternately on every second revolution, so that the engine has a very steady and even motion, due to the uniform turning moment. It is said to be particularly free from the vibration in machines having stationary cylinders, this vibration being due to the reciprocating motion. The oil for lubrication is fed by centrifugal motion. It is introduced through a hole in the shaft, and is thrown to all parts of the cylinders and working parts by the motion of the rotating parts. The engine may be used for operating pumps and electric generators, where great steadiness is essential. It was designed especially for automobiles, and has proved well adapted for hill-climbing, as it steps from low to high speed very quickly. This is due to the absence of change-speed gears. The 24 horse-power engine for light carriages is 24in. diameter and 14in. wide, with a weight of about 25 lb. The cost is considerably less than that of an ordinary engine of the same power. Some light machines of this design have been built for experimental service in driving the motors of aëroplanes and airships.

A pneumatic-electric coal drill.—A pneumatic-electric rock drill was described recently in THE ENGINEER, and the same system—but under different patents—has been applied to a drilling machine or "puncher" for coal mines. The blow is produced by the expansion of compressed air, and this air is compressed at each stroke of the piston. The piston compressing the air is operated by an electric motor which forms a part of the machine. The piston which operates the drill moves independently of the compressing piston. The only connection required is a cable conveying the electric current to the machine. The machine is small but long, mounted low on a pair of small wheels, and having at the rear end a handle by which the operator feeds and moves the machine. The motor is of the series-wound type, and a pinion on the end of the armature shaft drives a main spur wheel. An internal gear on this latter drives a pinion having a crank arm connected to a crosshead, and in this way the rotary motion of the motor is converted into reciprocating motion of a piston-rod and piston actuated by the crosshead. This is the compressing piston, but the drill piston in the same cylinder is drawn back with the other on account of the vacuum caused by the movement of the compressing piston. On the rear side of this piston the air is compressed on the back stroke, and at the end of the stroke this charge of compressed air is admitted to the space between the pistons. This drives the drill piston forward, and makes the cutting blow of the drill. The air escapes at the end of the stroke, but enough remains to cushion the blow. The compressing piston follows the drill piston, thus drawing in another charge of air behind the former. The air cushion prevents the pistons from coming together. The cylinder is 6½in. diameter, and the air pressure is about 100 lb. The machine weighs 800 lb., and requires about 7 horse-power for its operation.

Deepening the Detroit River.—The great size, and particularly the deep draught of the coal and cargo steamers on the Great Lakes of North America, has necessitated continual improvements of the lake ports and harbours, and also of the channels which connect the lakes. All this work is under the direction of the engineer corps of the United States army. In the Detroit River—which is part of the strait connecting lakes Huron and Erie—the deep channel is being improved and a new channel formed, so that there will be separate channels for the up-bound and down-bound steamers. Part of the work is done by dredgers, but a large proportion is solid rock excavation. One method employed is to drill holes from a floating barge, and explode blasting charges, the shattered rock being removed by dipper dredgers, which resemble floating steam navvies. On another part of the work a great cofferdam of dredged material was built, enclosing an area 6500ft. long and about 1500ft. wide. This was pumped out by means of fifty air-lifts, each having an 8in. water pipe and a 2in. air jet pipe. The rock excavation was then carried on in the dry. The channel will be 600ft. wide, and its sides are formed by channeling machines which cut a vertical groove. Between these grooves are drilled blast holes. The rock is loaded into large flat skips by steam navvies having broad wheels which run on the smooth rock floor. The skips are handled by cableways of 800ft. span, extending across the work. The depth of rock excavation is about 20ft. The cableway towers were built on artificial islands before the pumping was started, so that work could be begun as soon as the water began to go down.

A petrol-operated rock drill.—A percussive drill operated directly by the explosion of charges of petrol in an engine cylinder is now being introduced in the United States. The single-acting stope drill weighs 90 lb., but the regular rock drill is a double-acting machine and weighs about 175 lb. In appearance this latter very much resembles the ordinary compressed air drill. It has the usual tripod stand, supporting a vertical frame and cylinder, with the drill-rod at the bottom and the hand-feed screw at the top. It will drill

holes as deep as 30ft. In hard granite it can make 3in. per minute, and consume only a quarter of a gallon of petrol in half an hour's steady work. The working cylinder is a two-cycle double-acting gas engine. The charges are drawn in through ports at the upper and lower end; they are first compressed, then passed to the central part of the cylinder and there exploded, alternate explosions being for the up and down strokes respectively. The piston is double, having two plungers connected by a stem of smaller diameter, and a rod from the upper plunger is connected to a crank shaft. The drill-rod is connected to the lower plunger by a swivel which allows it to rotate, and there is an automatic device to rotate the rod so that the bit will cover the entire area of the hole. The crank shaft is cushioned, and the pistons are practically free from it when the rod strikes the rock, thus relieving the bearings from shock. The cylinders are of cast iron made hard by an admixture of steel; the pistons and other parts are nickel steel forgings. The packing between the explosion chambers is of Allen metal and will stand a temperature of 1500 deg. Fah. For use underground the exhaust may be carried by a hose to a waste pipe or with a special chemical solution.

A navy repair ship.—The United States fleet, which is now on its voyage around the world, is accompanied by the navy repair ship Panther, to provide for such repair work as cannot be done by the tools and mechanics of individual ships. This vessel is an outcome of experience in the Spanish-American War, when a temporary repair ship, the Vulcan, was fitted out as an auxiliary to the fleet. The Panther was formerly a passenger steamer running between New York and South-American ports, and was purchased for use as a cruiser in the above war. It is 320ft. long, 43ft. beam, with a draught of 15ft. 9in. and a speed of 13 knots. It has a coal capacity of 675 tons, and its loaded displacement is 3380 tons. In addition to the crew, it carries about 50 mechanics. Most of the machinery equipment is below the main deck, forward of the engines and boilers. There is a small woodworking department and pattern shop. The machine shop has six lathes, a milling machine, drills, dry and wet grinders, a planer, and a pipe-cutting and threading machine. All are driven by individual motors, except that five drills are run from one motor-driven shaft. For plate and similar work there are a punching and shearing machine, hydraulic bending press, and plate-bending rolls. For blacksmith work there are five stationary forges, a portable forge, three anvils—on cast iron blocks—a forge blower, and a steam hammer. For foundry work there are a 23in. cupola, a Schwartz furnace, and a Calerex melting furnace which uses crucibles. The furnaces are for brasswork. All these are in the hold, the cupola being charged from the machinery deck. The cupola stands in an enclosure or tray which is filled with sand. The casting and moulding room is 14ft. by 20ft., and has chain hoists running on the deck beams for handling ladles, copes and castings. Castings weighing 2500 tons can be made.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

LONDON AND NORTH-WESTERN SUPERHEATER LOCOMOTIVES.

SIR,—Neither in your admirable leading article on railway birth or the description of the London and North-Western Railway and its locomotives is reference made to the remarkable superheater locomotives of McConnell.

Surely, to judge from the importance given to the subject in the periodical literature of Messrs. Garbe and Schmidt, McConnell's smoke-tube and smoke-box superheater locomotives of 1852 and 1859 should be of far more historic interest than many of those to which you devote much attention. One of them is of world-wide interest, for the reason that the *Illustrated London News*, dealing with the results obtained in service with the first McConnell type of superheater locomotive, in 1855, stated that the power of the steam was found to be augmented 50 per cent. by the use of the McConnell superheater. Until that note was published in 1855 Hirn appeared doubtful of the value of superheating, but in the same year, after reading the note, he took out a patent for his "hypo-thermo-generator"—such, at least, is what has recently been revealed to us by an eminent authority. Yet Hirn has always been regarded as the first to investigate superheated steam practically, and even the catalogue of the Schmidt Superheating Company, Limited, dated July, 1907, "The Application of Superheated Steam to Locomotives," states that the subject was not scientifically investigated until Hirn took the matter up about 1857.

Yet in Crewe works we still find preserved the "Cornwall," the rebuilt engine of F. Trevethick, remarkable only for its 8ft. 6in. wheels; but no McConnell superheater locomotives! Very singularly, F. Trevethick was, as you comment—page vii.—"a son of *the* Trevethick"—son of the genius whose precedence in the practice of very high steam pressures is known, but whose efforts in the direction of superheat of very high temperatures are still unknown even to those who profess to be experts in this particular branch. Whether the son followed out in actual railway practice the superheater designs of his father there are probably no records left to show (?), but posterity will henceforth know the great Trevethick as the inventor of the sextuple-effect U-type bent-tube or return-tube superheater situated in the main boiler smoke-flue, parallel with the direction of the smoke-box flames, conveying the steam six times back and forth, in the same superheater element or series, along nearly the whole length of the boiler, and with proportions, water-tube generator to superheater, such that the use of a similar boiler applied to locomotives as Trevethick proposed would result in steam temperatures as high as those of modern steam motor vehicles. A few months ago some foreign correspondent asked if this superheater type was actually applied to railway locomotives, Trevethick's invention dating 1832 and his death occurring only seven months later; but it seems now that the information asked is not in the possession of those who are willing to reply in your correspondence columns.

December 14th. ARGUS.

CORROSION.

SIR,—In your issue of October 16th, 1908, we notice an article discussing the theory of corrosion recently introduced by Dr. Allerton S. Cushman, of Washington, D.C. We are greatly interested in this subject, because we have been striving for some time to manufacture a sheet metal which would be more resistant to corrosion than the ordinary grades of sheet metal in general use in this country. For years we conducted numerous experiments, at the expense of considerable time and money in an effort to solve this problem, without any marked degree of success. In 1905 Dr. Cushman wrote an article on the "Corrosion of Fence Wire," in which article he suggested that the large quantity of manganese in steel bore some relation to its rapid corrosion.

Following out this suggestion, our company began a series of experiments, in which the manganese in our material was gradually reduced, until to-day we are manufacturing a sheet in which the manganese amounts to merely a trace, the other impurities being reduced accordingly. This material is now guaranteed to contain no more than .06 per cent. of phosphorus, sulphur, carbon, manganese and silicon. This material is produced in a fifty-ton basic open-hearth furnace, and no manganese whatever is added either in the furnace or in the ladle.

Furthermore, in every known accelerated acid test for the determination of the relative resistance to corrosion of iron or steel and in various service tests conducted for a period of six months and a year, this product has shown a marked superiority in resistance to corrosion over various grades of steel containing the usual amount of manganese and also many samples of iron sheets. We feel deeply obliged to Dr. Cushman for the many valuable suggestions he has offered from time to time in his papers on the subject of corrosion, and we think he has rendered the country at large a great service by the deep study he has given this question. It has been our good fortune to be able to demonstrate beyond the peradventure of a doubt the feasibility and practicability of his suggestions along the line of reducing the impurities in our material. We have found that manganese is entirely unnecessary, and in omitting it we do not, as you have stated, have to add some other ingredient which might be equally injurious.

Fully realising the great help and benefits our company has gained from Dr. Cushman's article on corrosion of iron and steel, it becomes our duty to give you this information.

Please understand we do not offer this letter as a criticism, or in any other than a very friendly spirit, and we hope it will be received in like manner.

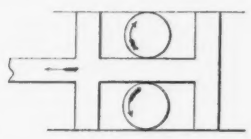
Middleton, O., November 30th. (THE AMERICAN ROLLING MILL COMPANY,) G. H. CHARLS, Assistant Secretary.

ROLLING RINGS: A PUZZLE.

SIR,—Perhaps some of your readers may find amusement in solving a puzzle which has beaten me and several friends.

In some water meters the piston is packed by a rolling ring of india-rubber, surrounding the piston and moving up and down with the piston through a distance equal to half the length of the stroke.

What goes on internally in this ring? As far as I can see its motion is a paradox, for any two sections of the ring taken at



opposite ends of a diameter are revolving in contrary directions at the same time, and yet the ring is continuous.

Let us suppose that the ring is cut up into discs, and that we take one at one side of the piston and another at the opposite side, and that the piston body is very small and the diameter of the discs is considerable, then we should have the condition shown in the accompanying sketch. It is clear here that when the piston moves in the direction of the arrow the discs will rotate in opposite directions. This is true of rings of any sectional diameter. The ring is not torn up—in fact, it is quite amenable. How does it do it? BOTHERED.

Brixton, December 12th.

FOUR-CYLINDER NON-COMPOUND LOCOMOTIVES.

SIR,—A letter appearing in your last issue says: "Whatever advantage compound engines may possess, when used for working slow trains with a heavy draw-bar pull, it is quite certain the advantage is at a discount when trains have to maintain a high average speed."

Can your correspondent, or any other, produce a series of comparative figures of results from which he, or they, have been able to draw such a conclusion?

This idea appears to be a tradition rather than a fact. As your correspondent is "certain" of it, some authentic figures substantiating his belief would be highly interesting.

In other countries, where compounding has been thoroughly tested and upon a scale dwarfing into complete insignificance the sporadic applications in this country, the high speed express engine working level lines has given the best results of all—up to 32 per cent. economy as an average, while the slow moving goods type engine working very heavy loads on the steepest of railway gradients is found to yield much less economy—about 18 per cent. and 20 per cent. A higher result with goods-type engine is stated to be attained by the L. and Y. engines, that is 25 per cent. economy, but this is unquestionably due to the fact that in this case the speeds are relatively higher and the loads and gradients less. As an actual fact, in properly designed compound engines, the greater the speed is the greater the economy.

The inferior results obtained in this country appear due to improper ratio of H.P.: L.P. cylinders which, according to modern practice, should be 1:2.9 at least; and no duplicate reversing gears to mar results.

In all countries where four-cylinder non-compounds have been tried against (properly designed) balanced compounds the single-expansion engines have shown higher fuel consumption. This is the case in Belgium and with completely modern and similar types of each class. Was not this also the case on the London and North-Western some years ago?

It is also a fact that compounds are faster than single-expansion engines. This is the reason, recently stated by an Anglo-American contemporary, for the present re-introduction of balanced compounds on a large scale by an American railway whose passenger traffic exacts the highest speeds obtainable by locomotives.

So far single-expansion engines have never approached on any railway in the world the high velocities attained and maintained for long stretches by compounds.

For high acceleration, compounds in foreign countries hold the first place against any system of engine, as judged, not by personal statements, but from masses of automatic train speed records available.

High pressures are not essential for compound working; long experience has shown that with very low pressures in compound and non-compounds of the same type, class, weight, boiler pressure, number of working parts, and train service, the coal economy varies from 14 per cent. in goods up to much higher figures, varying from 20 to 25 per cent., in engines having four cylinders in place of two.

December 14th. ARGUS.

HIGH-SPEED TOOL STEEL.

SIR,—In reference to your correspondent, Mr. E. R. Morrison, of Newcastle-on-Tyne, it is interesting to hear that he is able to weld high-speed steel to mild steel by an oxy-acetylene blow pipe. In all the inquiries I have made up to date of the value of oxy-acetylene welds, I find that although many attempts have been made they have not been found to be of any great strength, and when one considers the amount of pressure we get upon the point of a tool when doing any heavy work, it requires to be not only a surface weld but a weld which goes along the whole face of the two metals.

I fail to see how it is possible to weld a piece of high-speed steel either over the whole face or along a slot such as we do by fusion welding, as mentioned by Professor Carpenter before the Manchester Association of Engineers, nor do I see how it is possible to re-harden the steel after such a weld has been made.

I shall be very pleased to make a test of one of Mr. Morrison's tools side by side with one of our fusion-welded tools if he cares to send one, or shall be pleased to submit one of our tools to Professor Carpenter to be treated side by side with a tool manufactured by Mr. Morrison's process.

The whole crux of our process of welding tools is that the whole of the steel, both mild and high speed, is subjected to a heat equivalent to the melting point of copper, this allowing the copper to flow molecularly into the fibre of the respective steels, bringing the molecules of the faces of the two steels into continuity.

I do not know of any process by which a similar result is obtained, and no other result can, in my estimation, meet the case or be in any way satisfactory.

(FUSION-WELDED METALS, LIMITED.)
JOHN A. SMEETON.
London Managing Director.

London, December 14th.

STONE BLOCKS ON RAILWAYS.

SIR,—Attention has to-day been called to the use of stone blocks on railways. The article in THE ENGINEER on the London and North-Western Railway refers to stone blocks being taken up after a few months' trial, but an old permanent-way engineer calls attention to the gauge report of 1846. It says:—"The London and Birmingham had 70 miles 646 yards of double road on blocks; the Grand Junction had 62¼ miles; and the Liverpool and Manchester had 16 miles 37 chains in 1845." So blocks were in use for many years.

I know that blocks were in use on parts of the London and North-Western system for forty years, and on the Midland blocks had been in use from 1832 to 1870. I have three blocks in Leicester Museum which were in use from 1832 to 1904, or seventy-two years.

Stone blocks I know in 1868 were very hard to ride over, and Barlow's cast iron sleepers in Glenfield Tunnel were almost as bad.

Perhaps you will note the age of blocks with reference to the matter. CLEMENT E. STRETTON.

Leicester, December 14th.

DEPRECIATION OF MACHINERY.

SIR,—The recent discovery of the importance of depreciation accounts reminds one very strongly of the discovery by Monsieur Jourdain that he had been speaking prose for forty years without suspecting it.

There appears to be no substantial reason given as to why the early years of any undertaking should be heavily mulcted by writing off a fixed percentage from the diminishing balance, and it seems undesirable to add further complications by trying to obtain an absolute connection, or ratio, between an estimated depreciation rate and an imaginary earning power.

As the total of the depreciation account, plus the 5 per cent. residual value, is supposed to equal the original cost, it is but reasonable to assume that each annual instalment has interest earning power, whether used in the business, or invested as a renewal fund; therefore the accumulation at the end of twenty years will provide for renewals, and also sufficient for starting a secret reserve! This would be beneficial to the then holders of shares, but would have been provided at the expense of the early shareholders.

December 16th. A. WILLIAMS PRICE.

FREE FACTORY SITE OF TWO ACRES.

SIR,—I shall esteem it a favour if you will kindly insert this letter, which may be of interest to some of your many readers. I am authorised to offer, on behalf of the freeholder, a free factory site of two acres in this district. The owner is prepared to give these two acres of freehold land, near a station, to any manufacturer who will undertake to erect an approved factory, provided that the business is an established one, which would require a fair number of hands. Full details on application to

W. H. HOSKING, Surveyor.

Twickenham, December 10th.

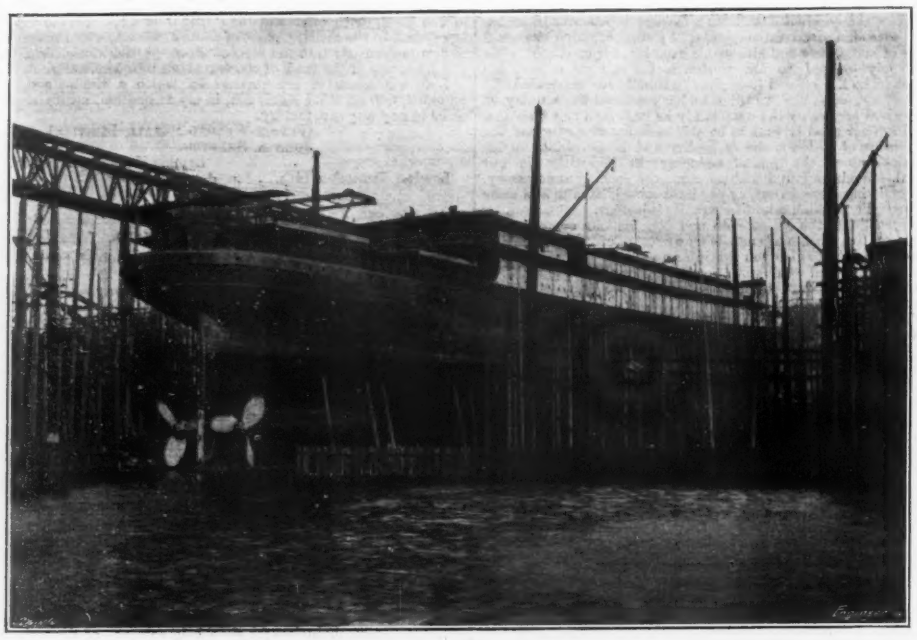
IN reply to Mr. John T. Middlemore, who asked whether the Admiralty had any intention of testing internal-combustion engines for propulsive purposes in any of the five protected cruisers for which orders had recently been given, the First Lord of the Admiralty replied that all these five protected cruisers had been designed with steam-turbine machinery, and that there was no intention of testing internal-combustion engines for propulsive purposes in any of them.

ROYAL INSTITUTION OF GREAT BRITAIN.—A Christmas course of experimentally illustrated lectures, adapted to a juvenile auditory, on "The Wheel of Life," will be given by Professor W. Stirling, M.D., LL.D., D.Sc. Tuesday, December 29th.—(I.) "The Breath of Life"; Thursday, December 31st.—(II.) "Consider the Lilies of the Field"; Saturday, January 2nd.—(III.) "Daily Bread"; Tuesday, January 5th.—(IV.) "Rivers of Life"; Thursday, January 7th.—(V.) "Sentinels and Citadels"; and Saturday, January 9th.—(VI.) "Work, Fatigue, and Repose." Lecture hour, 3 o'clock.

YORKSHIRE RAILWAY COAL CONTRACTS.—Our Barnsley correspondent, writing yesterday, says:—A somewhat startling change has come over the Yorkshire steam coal trade, which is materially reducing railway and other large contracts for next year, when when some of the companies will save fully 2s. 6d. per ton. The market has for some time shown a downward tendency, but it was hoped 9s. per ton would be received for South Yorkshire hards. The events of the last week have dispelled this, for several large shipping contracts have been placed at 8s. per ton at the pits, and has insured both the North-Eastern and Lancashire and Yorkshire Railway companies securing coal from collieries on their own line on the basis of 8s. 6d. per ton for South Yorkshire hards. The Midland Railway Company, whose South Yorkshire coal contracts at 9s. 6d. per ton run to the end of March, is placing contracts in Notts and Derbyshire for next year at lower rates than the expiring contracts. Two important contracts with shipping firms have just been made which will doubtless fix the prices for local steam coal for shipment next year. The Dalton Main Colliery Company, Limited, last week accepted a contract for not less than 50,000 tons from Messrs. Elder, Dempster and Co., of Liverpool, to be delivered at that port during next year. The price has not been made known, but it is said not to exceed 8s. per ton at the pit. Be this as it may, the newly developed Brodsworth Main Colliery have concluded negotiations with a well-known Hull shipping firm for supplies over next year of 75,000 tons, to be delivered at the rate of 1500 tons per week, f.o.b. at Hull, at 11s. 1d. per ton. This makes the pit price scarcely 8s. per ton. It is anticipated that the Hull and Grimsby Steam Trawling companies will obtain their supplies on similar, if not lower, terms, which will show a marked contrast with the attempt at the beginning of the year to enforce 11s. 6d. to 12s. per ton. It is stated that the South Yorkshire coalowners intended, in view of the bearing of the Mines Eight Hour Bill, to quote two prices in their contracts, but recent events have prevented this being done.

THE WHITE STAR LINER MEGANTIC

HARLAND AND WOLFF, LIMITED, BELFAST, BUILDERS

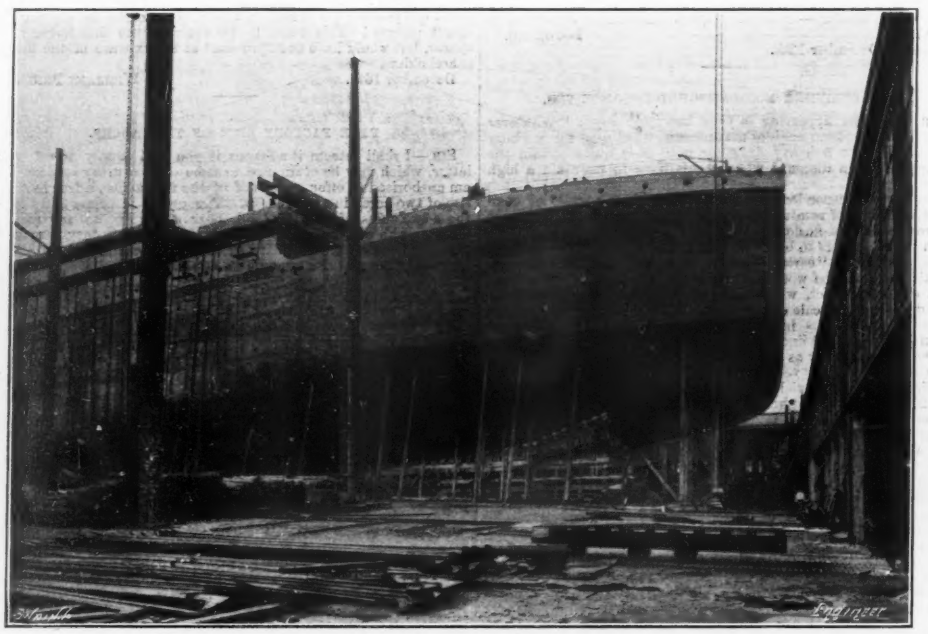


THE WHITE STAR-DOMINION LINER MEGANTIC.

ON Thursday, the 10th December, the twin-screw steamer Megantic was launched by Harland and Wolff, Ltd., Belfast. She is a sister ship to the Laurentic, which was launched last September, and which, it is expected, will be completed early next year. Although similar to the Laurentic in every other respect, the Megantic has twin-screws, whereas the Laurentic is a triple-screw steamer, consequently these vessels although exactly similar in their appointments will each represent a distinct principle in marine propulsion. The Megantic will stand for the highest perfection of the twin screw "balanced" reciprocating engine, while in the Laurentic the combination of reciprocating engines and low-pressure turbine has been introduced.

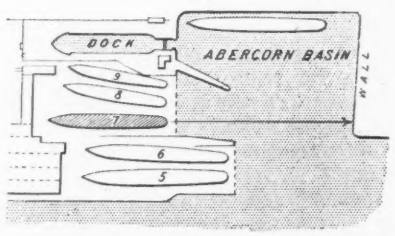
Special interest is being manifested in these two vessels, as they will signalise the entry of the White Star Line into the Canadian trade, a development to which those interested in the trade between the Mother Country and the Dominion are eagerly looking forward. Probably in no part of the Empire is there greater industrial and commercial enterprise at present than in Canada, and the new connection so soon to be entered on by the White Star Line is bound to give a great stimulus to the spirit of enterprise, thus tending still further to strengthen those ties which bind the Colonies to the Mother Country.

The Megantic and Laurentic will be the largest vessels in the Canadian trade, being 565ft. long by 67ft. 4in. beam, and about 15,000 tons gross. They are designed to carry a large quantity of cargo and also a full complement of passengers—about 260 first-class, 430 second-class, and over 1000 third-class. The Megantic has been built on the cellular double bottom principle, the double bottom extending the whole length of the ship, and specially strengthened under the engines to give still greater rigidity in the vicinity of the machinery. The vessel has nine water-tight bulkheads, dividing her into ten water-tight compartments. There are six cargo holds, and the bunkers are specially arranged to facilitate the coaling. The hull has handsome lines, and when complete the Megantic will undoubtedly have a very fine appearance. There was a good bit of fog at the time of the launch, which prevented a good photograph being obtained, but through the courtesy of Harland and Wolff, Ltd., we are enabled to reproduce two photographs of the vessel on the stocks, these showing a bow and a stern view respectively. From these the elegance of the lines is readily appreciated.



BOW VIEW OF THE MEGANTIC ON THE STOCKS

The derricks and other appliances for working the ship and cargo are of the latest pattern, special attention having been paid in the design of the vessel to the requirements of shippers in the Canadian trade, and the vessel will have large refrigerating chambers both for provisions and cargo.



THE LAUNCH OF THE MEGANTIC

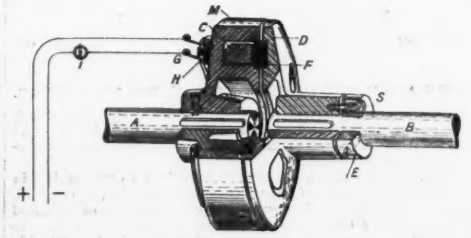
The passenger accommodation has been arranged on a generous scale. A feature of the entrances and public rooms will be their height and general roominess, and the state-rooms will have the same characteristic. The first-class state-rooms will be situated in a deckhouse on the lower promenade deck, and also on the shelter deck. There will be a number of cabins *en suite*, with a private lavatory and bathroom adjoining each suite. The first-class saloon on the middle deck will be a very handsome room, panelled and framed, finished flat white, relieved with elaborate carving. The dado and furniture will be in oak, and the floor parquetry. The saloon extends the whole width of the vessel, and will have seating accommodation for 160. It will have the popular "well" arrangement overhead, with a verandah for the bandstand. The first-class lounge on the upper promenade deck will be in Louis XV. style, artistically panelled in oak and with a parquetry floor. The reading-room on the same deck will be in white; in the style after Adam Bros. This room will also have a parquetry floor. The first-class smoke-room on the upper promenade deck will be decorated with embossed leather and carved framework round the windows. The furniture will be of mahogany and the floor india-rubber tiles. There will be an electric passenger lift serving four decks.

The second-class state-rooms are on the shelter deck, the saloon—a fine apartment extending the whole width of the ship, and capable of seating 262 persons—on the middle deck. The second-class library is on the lower promenade deck, and the smoke-room on the upper promenade deck. The second-class passengers on this vessel will find the provision made for their comfort second to none on the Atlantic. The third-class dining-room, which is aft on the upper deck, is also an exceptionally good room, extending the whole width of the ship. The vessel will be fitted up with the latest Marconi system of wireless telegraphy, and will also have a submarine signalling apparatus.

The Megantic was launched from Slip No. 7 in Messrs. Harland and Wolff's yard into the Abercorn Basin. From the accompanying sketch-plan it will be seen that space is very restricted, there being a granite wall right in front of the launching ways, which only allowed some 64ft. to spare when the vessel became water borne. However, the arrangements made for bringing her up, which included six cables and drags, were so complete that she was, we are informed, actually stopped in less than 12ft.

ELECTRO-MAGNETIC SHAFT COUPLING.

A NEW form of electro-magnetic shaft clutch or coupling has recently been introduced by the Berlin-Anhaltsche Maschinenbau Aktien Gesellschaft. As will be seen from the illustration below A and B are the two shafts which it is desired to couple; M is an electro-magnet keyed and pinned on the shaft A; D, an armature keyed on, and capable of being slid along, the shaft B; E is a collar fastened on the shaft B, and between it and the hub of the armature D there are spiral springs S; between the two discs—the magnet and the armature—there are friction rings F of non-magnetic material;



ELECTRO-MAGNETIC SHAFT COUPLING

C is a coil, receiving current from the conductors, seen at the left; there being a slip contact piece G and a contact ring H; I being the switch.

When the current is turned into the coil, the disc A becomes magnetic and attracts the armature B; but these two never actually touch each other, the friction necessary for transmission being provided by the two rings of non-magnetic material. No lubrication of the rubbing surfaces is necessary. As regards the amount of electrical energy necessary for working this clutch, it is stated to be, for clutches of ordinary dimensions, 220 volts tension, and from ½ to 1 ampère, say 110 to 220 watts. The function of the springs S is to draw the plate D away from the magnet M when the current is cut off.

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—A general meeting of this Association was held at the Institution House, Storey's-gate, Westminster, S.W., on Monday, December 14th, 1908, at 8 p.m. The chair was taken by Mr. Arthur Greenwood. A paper, entitled "Commercial Precision Grinding," was presented and read by Mr. Reginald Bishop. The author opened his subject by treating with the position of the grinding machine in up-to-date works, and the necessity and utility of such apparatus for dealing with hardened work, and the ever-widening scope that such machines are likely to embrace, especially in conjunction with the high-speed roughing lathe as a finishing tool. Particulars regarding the structures of the several abrasives now in use, their relative qualities and methods of production, as well as their manufacture into abrasive wheels for use in grinding machinery, were also discussed. The author gave some useful information regarding the grading and numbering of wheels for the purpose of distinguishing between hard and soft wheels, and touched upon the most suitable wheels for various purposes. In treating the subject of the machines themselves, the author confined himself to plain cylindrical grinding apparatus, and proceeded to place before the meeting details of various prominent makes of machines for this purpose, both of the plain and universal type. The author also offered many useful suggestions regarding the grinding of internal work, upon which subject he had devoted a good deal of time and experience. A discussion of the relative merits of wet grinding as against dry grinding, the use of lubricant, precautions taken to avoid distortion of the work, and other salient points incidental to the latest practices in this branch of manufacturing engineering, was also embodied in the paper. The discussion following the paper was opened by Mr. Percival Petrie and the chairman of the evening, and the following graduates took part:—Messrs. A. B. E. Cheeseman, M. G. Duncan, G. H. Humm, and A. B. Symons. By the kindness of Messrs. Clement Talbot, Limited, arrangements have been made to visit their works on Saturday afternoon, December 19th. Graduates will meet outside the works, Barlby-road, Ladbroke-grove, North Kensington, W., at 3 p.m.

THE WRIGHT AND VOISIN TYPES OF FLYING MACHINE: A COMPARISON.*

By F. W. LANCHESTER.

THE most successful types of flying machine or aëroplane at present in existence are those constructed by the brothers Orville and Wilbur Wright, of the United States, and by MM. Voisin Frères, of Billancourt, Seine, France, on the outskirts of Paris. The author of the present paper has recently had opportunities of witnessing both types of machine in flight, the former at the Champ de Manœuvres at Champagné, near le Mans, the latter, in the hands of Mr. Farman, over the ground of the military camp at Mourmelon-le-Grand, near Chalons.

Although accurate information is on some points difficult to obtain, the reticence shown is perhaps no more than might be anticipated. The author has succeeded in collecting sufficient data to be able to give a consistent account of the performance of both machines, and to permit of an intelligent comparison being made between the two systems.

The Wright machine: Origin and description.—The Wright machine can, metaphorically speaking, trace its ancestry back to the gliding apparatus of Otto Lilienthal. According to Gustave Lilienthal, brother of the famous aëronaut, two Lilienthal machines were sent to the United States—one to Octave Chanute, the other to Herring; Chanute and Herring are said to have been associated in their experimental work. The gliding machine, originated by Lilienthal, was improved, especially as to its structural features and its method of control, successively by Chanute and the brothers Wright, until the latter, by the addition of a light-weight petrol motor and screw propellers, achieved, for the first time in history free flight in a man-bearing machine propelled by its own motive power.

The Wright machine of the present day weighs complete, when mounted by aëronaut, 1100 lb. (500 kilos.), and has a total supporting surface measuring approximately 500 square feet; the ordinary maximum velocity of flight is 40 miles per hour, or 58 ft.-sec. (= 66 kiloms. per hour). The aërofoil consists of two equal superposed members of 250 square feet each, the aspect ratio—lateral dimension in terms of fore and aft—is 6.2; the plan form is nearly rectangular, the extreme ends only being partially cut away and rounded off. The auxiliary surfaces consist of a double horizontal rudder placed in front and a double vertical rudder astern, also two small vertical fixed fins of half-moon shape, placed between the members of the horizontal rudder. The total area of these auxiliary surfaces is about .3 of that of the aërofoil—or, say, 150 square feet. The Wright machine is propelled by two screws of 8ft. 6in. diameter (2.6 m.), and, so far as the author has been able to estimate, the *effective* pitch is somewhat greater, being about 9ft. or 9ft. 6in. These propellers are mounted on parallel shafts 11ft. 6in. (3.5 m.) apart, and are driven in opposite directions by chains direct from the motor shaft, one chain being crossed. The number of teeth of the sprocket wheels, counted by the author, gave the gear ratio 10 : 33.

The motor is of the four-cylinder vertical type, the cylinder dimensions being variously given as from 106 mm. to 108 mm. diameter by 100 mm. to 102 mm. stroke, the probable dimensions being in inches 4¼in. by 4in. The total weight of the motor is reputed to be 200 lb. (90 kilos.), and its power is given as 24 brake horse-power at a normal speed of 1200 revolutions per minute. According to another source of information it is capable at a speed of 1400 revolutions of developing 34 brake horse-power; the two statements do not altogether agree.

In conversation the author understood Mr. Wright to say that he could fly with as little as 15 or 16 horse-power, and that his reserve of power when unaccompanied amounted to 40 per cent.[1] His gliding angle he said was about 7 deg.

The Voisin machine: Origin and description.—MM. Voisin began their experimental work some years before their name was known to the general public, or, rather, some years before their machines came into public prominence through the exploits of Farman and Delagrange, for comparatively few people even at the present time are even aware of the name of the makers of these most successful machines. In 1904 MM. Voisin constructed for Mr. Archdeacon some cellular kites of a large size, of very much the form of their present type of machine, these were tested in tow of a motor launch on the Seine, and provided much of the data that MM. Voisin afterwards utilised in the construction of the actual flying machines that brought their work into public prominence.

The MM. Voisin and their engineer or works manager, M. Colliex—who is largely responsible for their designs—make no secret of the fact that they have based their work on that of pioneers such as Lilienthal, Langley, and others; and, in fact, they say that they never miss an opportunity of utilising any information or data on which they can lay their hands. On the other hand, much of their work is based on their own researches, they appear to take little for granted, having equipped themselves with an "artificial wind" apparatus, with which they test their work on a small scale before finally settling a design.[2]

The Voisin factory is on a comparatively small scale; the output and work in hand at date includes, amongst others, some five machines of the Farman-Delagrange type, and four machines of a modified pattern, with an aërofoil consisting of three superposed members. The former is the only type of machine for which flight data are to hand, and in the remarks that follow it is this type to which reference is made as the Voisin machine.[3]

It appears from statements made to the author by MM. Voisin, and confirmed by M. Farman himself, that when their designs were prepared, the first order they obtained was from M. Delagrange, and the second from M. Farman, who placed his order for what was practically a duplicate machine. That Farman made successful flights before Delagrange was due, in the main, to the fact that he had made in advance appropriate arrangements for testing and trials on the Champ de Manœuvres at Issy des Moulineaux, a precaution that the latter neglected, and it would seem that it is hopeless to attempt to fly, at least with a new machine, without some such provision. It also appears that the Delagrange machine went through some kind of a history in its early state, the wheels fitted in the first instance not being arranged as it was subsequently found necessary to arrange them, namely, as castors, or, as the French express it, "orientable." It is this provision that takes care of any slight side component of the wind when starting and alighting which might otherwise upset the machine.

The Voisin machine is given as weighing complete, with M. Farman "up," 1540 lb. (700 kilos.), and has a total supporting surface of 535 square feet, this being the combined area of the horizontal members of the aërofoil and the tail, both being used for sustentation, although there are reasons for supposing that the pressure per square foot on the aërofoil is greater than on that of the tail.

The ordinary maximum velocity of flight is approximately 45 miles per hour, or 66 ft.-sec. (= 72 kiloms. per hour).

In addition to the horizontal sustaining members of the aërofoil and tail, there are a number of vertical members whose function is to preserve and control the direction of flight and to give lateral stability; these have a total area of approximately 255 square feet.

The supporting surfaces of both aërofoil and tail are of rectangular plan form, the former being 10 m. by 2 m., and therefore having an aspect ratio = 5. The aspect ratio of the tail members is 1.25; they are nearly square.

The Voisin machine is propelled by a single screw of 7ft. 6in. diam. (2.3 m.), of which the effective pitch is approximately 3ft.—the actual pitch is much greater, the "slip" being excessive. The propeller is keyed direct to the motor shaft.

The motor fitted to the Voisin (Farman) machine is an 8-cylinder "Antoinette," 4.35in. diam. by 4.15in. stroke (110 mm. by 105 mm.) stated to give 49 brake horse-power at 1100 revolutions per minute; its weight is given as 285 lb. (120 kilos.).

It is said that the gliding angle of the Voisin machine was at first approximately 1 : 5 or 11 deg, but that by detail improvements in diminishing framework resistance by rounding off and covering in to form stream-line sections the gliding angle has been improved, and is now about .16 radian, that, is between 1 : 6 and 1 : 7, or 9 deg. approximately.

COMPARISON OF THE TWO MACHINES.

Weight.—The first point to which we may direct our inquiry is that of the difference of weight. The Voisin machine is 40 per cent. heavier than that of the brothers Wright. Since the passenger accommodation of the two machines is almost identical—both machines have shown themselves capable of raising one person of ordinary size in addition to the aëronaut—it might be supposed that the less weight of the Wright machine is a definite advantage; in fact, it might be thought that the less weight betokens more scientific design; claims in this direction have, in fact, from time to time been made.

There is, however, one feature in which the machines differ, and which is unquestionably responsible for much of the difference in weight. The Voisin machine is fitted with a "chassis" with four wheels mounted to swivel freely, this being an essential feature of a well-designed alighting mechanism; the front wheels are provided with a spring "suspension" to diminish the shock of landing or consequent on starting or alighting on rough ground. The Wright machine has no such provision, but possesses instead a pair of wooden runners of comparatively little weight.

The total weight of this "chassis" of the Voisin machine is said to exceed 1 cwt. (50 kilos.), and, even if this is an exaggeration, it certainly cannot be far short of that amount, and probably exceeds the corresponding weight carried by the Wright machine by at least 60 lb. or 70 lb. Now, the total inert load carried by the two machines is otherwise about the same, and may be taken as about 200 lb., representing the aëronaut and sundries, and it is evident that, other things being equal, the total weight of the machine should be proportional to the inert weight it has to raise - that is, in the ratio of 200 lb. to 270 lb., or thereabouts—and thus the greater weight of the Voisin machine is in most part explained.

If the runners of the Wright machine would do all that can be done by the Voisin mounting, then this additional weight would not be justified, but they will not do so. The Voisin machine can rise by itself from any reasonably smooth surface; the Wright is unable to take flight without its launching gear,[4] hence it is not legitimate to attribute its relative lightness to the superiority of its design.

Horse-power.—The next point of comparison is that of the horse-power employed as related to the weight and velocity, thus touching on the question of the relative efficiency of the two machines.

The author has shown[5] that for equal perfection of design the resistance to flight of two machines of equal weight is approximately independent of the velocity of flight, consequently the horse-power will vary directly as the velocity of flight, and the Voisin machine is entitled to more power both on account of its greater weight and on account of its greater velocity. In the absence of more exact information, we may take the velocity of the Voisin machine as being 10 per cent. greater than that of the Wright. This is roughly in accordance with the figures already given.

The declared brake horse-power of the motors is sometimes not very reliable; it is customary to use the expression in a rather elastic manner. Let us make an estimate based on the cylinder dimensions and revolution speed of the two engines, assuming the same mean pressure for both. Employing the figures already given, and, for the purpose of comparison, assuming a mean pressure = 72 lb. per square inch as appearing at the brake, we have, at the speeds corresponding to the declared brake horse-power:—

	b.h.p.
Wright, 4.25in. × 4in. at 1200 revs.	24.7
Voisin (Antoinette), 4.35in. × 4.15in. at 1100 revs.	49.2

which agree remarkably well with the declared horse-power in both cases.

It is still questionable whether the declared speeds of revolution are those actually employed in flight. The author believes that in both cases the speeds are, if anything, understated, at least for the ordinary conditions of flight; they may, however, be taken in good faith, and we accept as a fact that the brake horse-power supplied to the Voisin machine is almost exactly double that fitted to the Wright.

On the above basis the Wright machine is fitted with 1 brake horse-power for every 45 lb. sustained, which rate would give the Voisin machine 34 brake horse-power, or allowing for the difference in the speed of flight, 38.5 brake horse-power should be sufficient to place the machines on an equal footing. But the actual brake horse-power of the Voisin is 49.2, or an excess of about 28 per cent., and this excess must either be accounted for as a surplus of power, the measure of which is the rate that the machine can increase its altitude, or it represents a loss of efficiency in the propulsion or sustentation.

Now there does not seem to be any substantial difference between the reserve lifting power of two machines, they both appear to have about 10 or at most 20 per cent. surplus power. Mr. Wright has claimed more, but the performance of his machine does not seem to bear out his claim.[6] We may consequently infer that the loss of power in the Voisin machine is correctly represented by the foregoing figures.

We will now endeavour, with the data at our disposal, to ascertain the cause of the loss of efficiency in the Voisin machine. The flight velocity and the motor revolution speed, together with the ratio of the gear reduction in the case of the Wright machine, allow us to calculate the effective pitch of the propellers; we already know their diameter, and from the pitch diameter ratio we can form a close estimate of their efficiency, we shall then be able to form an estimate of any remaining difference in the efficiency of the two machines.

Without going into the method by which the computation of the propeller efficiency is effected, it may be remarked that the method involves the assumption that in each case the designers have approximately determined the form of best efficiency under the restricted conditions of the pitch-diameter ratio adopted. That this assumption may not always be correct is obvious, but that it is somewhere near the truth in the two cases under discussion the author has been able to satisfy himself.

The method beyond this consists of a simple and elementary application of the principles laid down in the author's "Aërodynamics," Ch. IX.

First, to determine the effective pitch. This, in the case of the Voisin machine, is given by the distance travelled, divided by the number of revolutions in the same time. In the Wright machine the result has to be multiplied by the gear ratio. In the case of the Voisin machine we have 66/18.3 = 3.6ft. as the effective propeller pitch; in the Wright machine we have $\frac{58 \times 33}{20 \times 10} = 9.6$ft.

Or, the diameter in terms of effective pitch in the two cases is: Voisin, 2.1; and Wright, .88.

The efficiencies found by the author as appropriate to these pitch ratios are respectively:—Voisin, .54; Wright, .68; or deducting in the latter case 5 per cent. on account of the chain drive—certainly not a too great allowance for the power consumed by a chain running at about 16 foot-seconds—we have the total efficiency of propulsion—Voisin, .54; Wright, .63.

In the Table that follows No. 1 gives the foot-pounds given out by the respective motors per revolution on the basis already employed, *i.e.*, 72 lb. per square inch mean pressure; No. 2 gives the feet traversed by the machine per motor revolution; No. 3 gives the efficiency of propulsion, as above; No. 4 gives the thrust in pounds calculated from the three preceding numbers; No. 5 gives the weights of the machines augmented by an amount that we have estimated would absorb the whole thrust in horizontal flight, that is, the maximum weight that can be sustained in flight; No. 6 gives the resulting value of tan γ; and No. 7 gives the equivalent in degrees.

	Wright.	Voisin.
1. Foot-pounds per revolution	708 ..	1550
2. Feet per revolution	2.9 ..	3.6
3. Efficiency	.63 ..	.54
4. Pounds thrust	155 ..	230
5. Weight	1300 ..	1720
6. Tan γ	.12 ..	.135
7. γ °	7° ..	7° 40′

It would thus appear that, in addition to being considerably less efficient in its screw propeller—a tax paid for the constructional advantage of a direct drive - the Voisin machine is also slightly less efficient considered as a glider; that is to say, its gliding angle is not quite so good as that of the Wright machine, the machine is aërodynamically less efficient.

The reason of this may be due to the fact that it has a less aspect ratio, but it may quite well also be due to many other causes; the Voisin machine has relatively greater idle surface subject to skin friction, also the sustaining surfaces of the tail act on air that has already been trodden by the aërofoil.

The author is not altogether satisfied that the gliding angle is actually as low as that deduced above; it is possible that the motor—with the machines at the velocity stated—in both cases runs somewhat faster than that declared, and that consequently the pitch of the propellers is proportionately less, since this has been deduced from the revolution speed. An error of this kind, so long as it is much the same for both machines, would not materially affect the results, except that in both cases the gliding angle would be proportionately greater; the error may possibly amount to a matter of about 10 per cent.

It is also worth while noting that what is termed the mean or actual pitch of the propeller blades will be greater than the effective pitch; the pitch as measured from the blade angle is probably in the Wright propeller about 15 per cent. more than the effective pitch, and in the Voisin about 25 per cent. On this basis the Voisin 3.6ft. becomes 4.5ft. (= 1.37 m.), and the Wright 9.6ft. becomes 11ft. (= 3.35 m.).

Taking the gliding gradient tan γ for the Wright machine as .135, and that of the Voisin machine .150—values which the author considers most probably a close approximation to the truth—we may roughly look upon the resistance as accounted for as follows:—

	Wright. lb.	Voisin. lb.
Skin friction ξ = .01	40 ..	60
Struts and wires	30 ..	20
Aëronaut, motor, &c.	10 ..	10
Radiator and tanks	5 ..	25
Alighting gear	— ..	10
Sustentation (power expended aërodynamically) ..	60 ..	100
	145	225

The above do not correspond exactly with the suggested values of tan γ, but they are as near as the author can estimate at present. The addition in the case of the Wright machine is a trifle high, and that of the Voisin is a little low. Possibly the fault is with suggested values themselves, and there is really less difference between the gliding angles than has been supposed.

In conversation with the author, Mr. Wilbur Wright has stated that he makes no allowance for skin friction, and that he believes it to be negligible. There is evidently considerable scope yet for guesswork. It is quite likely the designers themselves could not give a much better approximate balance-sheet of the resistance account than that here presented. It is possible that the coefficient of skin friction ξ is less than .01; for these large surfaces and high velocities it is conceivably no more than half this value. It is equally possible that the other direct resistances, struts, wires, &c., have been underestimated. There may also be faults of as much as 10 or 15 per cent. in the estimate of the energy expended in sustentation, but it is quite certain that skin friction is not negligible, but that it is a substantial quantity of the order indicated. It is also quite certain that the gliding angle of the machines is round about the values given, 1 : 6 to 1 : 8, and is nowhere near 1 : 12, as has been stated in a recent paper on the subject. It is also improbable that the efficiency of propulsion is in any case as high as 75 per cent, as it has sometimes been represented—in the case of the Wright machine—although it may in both cases be a few per cent. greater than given in the present paper.

On the whole the advantage certainly rests with the Wright machine from the aërodynamic standpoint.

Stability.—We now pass on to consider the question of stability and control.

(A) *Longitudinal stability.*—In the case of the Wright machine it is claimed by Mr. Wright himself that the stability depends entirely on the skill and address of the aëronaut. In fact, if we are to credit the account of Mr. Wright's declaration on the subject,[1] he does not believe in the possibility of safety, under ordinary weather conditions, being achieved by the inherent properties of the machine; he says that sooner or later the fatal puff must come that will end the flight.

The author's own observations on the flight of the Wright machine fully confirm the statement that Mr. Wright does depend entirely upon his manipulative skill. It appears that in flight the

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* Paper read before the Aëronautical Society of Great Britain, December 8th, 1908.

[1] The author is of opinion that although there may be nothing altogether inexact in this statement, it is, unless qualified in some way, capable of conveying an erroneous impression.

[2] It is of interest to note that the MM. Voisin and their staff are entirely responsible for the design of their machines, and guarantee that they will fly. The purchaser pays for his machine in part as a deposit and the remainder when the machine has actually flown.

[3] So far as the author is informed the "triplane" type of Voisin machine—Goupy I.—has not performed so well as the earlier model—Farman type—though this may be due to the short time that it has been in the hands of the aëronauts. The author believes that the three members of the aërofoil are relatively too close to one another for best efficiency; their aspect ratio also is not good. Beyond this the position of the propeller—in front—is one not conducive to the best efficiency, and the race of the propeller in such a position may materially add to the body resistance.

[4] It has been recently reported that the Wright machine has undergone alterations by which it is enabled to rise from the ground by its own power. Whether the machine has been fitted with permanent wheels or whether it has been mounted temporarily on a trolley, which it leaves behind when it rises, the account does not say; probably it is the latter.

[5] "Aërial Flight," Vol. II.: Aërodynamics, Chapter VII.

[6] The rate of increase of altitude of a machine having a reserve of 40 per cent. would be quite sensational. Thus, at 1000 m. per minute velocity, the power required for horizontal flight may be represented by a loss of altitude of about 130 m. per minute, and an additional 40 per cent. would give an actual rate of ascent of over 50 m. per minute. The Wright machine does not, in the author's opinion, show so great a capacity of ascent. At the time of the author's visit a passenger of about 60 kilos. weight was being carried, the machine should still have been able to rise at a rate of over 1 m. in two seconds. It is on record that on one occasion Mr. Wright took up with him a passenger weighing 100 kilos., but, on the other hand, on another occasion he failed after repeated attempts to raise another passenger of approximately this weight; it may consequently be inferred that an addition of 10 kilos. to the 500 kilos. normally carried—that is an addition of about 20 per cent.—represents approximately the limit of the capacity of the machine. Beyond this Mr. Wright has admitted—at least, to the author—that his gliding angle is about 7 deg.; this at a gross weight of 1100 lb. gives 140 lb. thrust required, and at 58 foot-seconds the thrust horse-power becomes 14.5. Now, Mr. Wright also agrees 24 brake horse-power as the power of his motor, which, if 40 per cent. in excess of his requirements, gives 17.1 brake horse-power as ordinarily utilised, or the total efficiency of gear and screw propeller would be 85 per cent.—a manifest absurdity. If Mr. Wright's statement may be taken to mean that the *thrust* horse-power required is about 15 to 16 horse-power, and that his reserve of power is 40 per cent., to include that lost in propulsion, then the whole matter is clear. It is possible that the author misunderstood Mr. Wright's meaning.

[1] See account of speech at banquet given by Aëro Club de France *York Herald* (Paris edition), November 3rd, 1908.

leading plane travels through the air carrying little or no load; in the ordinary conditions of straight flight their direction is as nearly as can be estimated parallel to *the frame* of the main aërofoil, and both seem to move almost exactly edgeways. It follows from this that the machine cannot be automatically stable; for if the plane were fixed for any period of time, and if during that period the machine made the smallest pitching movement either one way or the other, the resulting change of pressure on the leading plane or planes would tend to exaggerate the initial movement, and the machine would turn over. The position of the machine with the leading planes fixed is comparable to an arrow travelling feather first, and this condition is one of instability.

In brief, not only does Mr. Wright design definitely for hand-controlled equilibrium, but he has no belief in the possibility of making a machine safe by its own inherent stability. The success of the Wright method shows that there is at least more than one way of flying.

In the Voisin machine, on the contrary, it has been the intention of the designer that the machine should be automatically and inherently stable, and unquestionably, to a great extent, he has succeeded. The author is at present compelled to speak with some reserve as to the degree of success that MM. Voisin have achieved; they have promised to supply particulars that will enable the point to be investigated, but up to the time of writing this promise has has not been redeemed. In the meantime, it may be remarked that the dispositions of the organs of the Voisin machine are such as will give automatic stability if the following conditions are fulfilled:- (1) If the pressure is less (per square foot) on the tail than on the main aërofoil, so that the attitude of the aërodrome to its line of flight is one of stable equilibrium; (2) if the areas and disposition of the surfaces, the amount of inertia, the velocity of flight, and the natural gliding angle, are related to comply with the equation of stability[1] so that any oscillation in the vertical plane of flight will not tend to an increase of amplitude.

From the behaviour of the machine it is not possible to tell whether these conditions are complied with, because it is fitted with a horizontal rudder in front, by which the aëronaut can correct any departure from the straight line, and this appliance is unquestionably utilised to destroy any oscillation that would otherwise arise; it is a big rudder about one quarter the area of the aërofoil, and skilfully handled it would entirely mask the natural free oscillation period of the machine. From observation of the flight the author is of opinion that whether or no the machine has inherent stability or not, the actual fact is that its motion—in the sense under discussion—is just as much hand controlled as the Wright machine. In the hands of a beginner the machine would, however, very likely be able to take care of the aëronaut to some extent, performing oscillations the while, until the aëronaut has learned to take care of the machine; this view is suggested by the fact that many of the observers who saw Farman and Delagrange early in their career witnessed the phugoid oscillation, whereas the author who saw Farman only a few weeks back, could not detect any oscillation at all, except for a brief period after he first left the ground, and this in spite of the fact that the day was by no means calm, a very perceptible breeze was blowing.

M. Colliex, engineer to MM. Voisin, claims that the flight path of their machine is stable on the following grounds:—(1) A one-tenth scale model showed itself quite stable in gliding flight. (2) A machine mounted by Delagrarge made a smooth glide to earth without the intervention of the aëronaut in any way when the ignition was cut off at 8 m. altitude.

The first of these tests would be quite satisfactory if due precautions are taken to ensure that the model test is made under the conditions of corresponding speed. As a matter of fact, the velocity of the model was nearly half that of the full-sized machine, instead of slightly less than one third, as it should have been. In consequence, it follows from the equation that its factor of stability was about three times that of the full scale machine, so that the experiment cannot be considered conclusive. The evidence of the flight of the actual machine in the hands of Delagrange also is insufficient, for the horizontal distance that the machine would glide from a height of 8 m. altitude would be approximately 55 m., and this is something less than one quarter of a phase length. For this test to be considered satisfactory, the machine should be allowed some four or five free oscillations, and the phase length being about 600ft., this involves a flight path of about 3000ft. length, or a fall of about 500ft., that is, 150 m. There is thus no proof at present forthcoming as to the stability or otherwise of the flight path of the Voisin machine, but it is at least the intention of the makers that it should be longitudinally stable, and, from conversations that the author has had with the MM. Voisen, and with their engineer, M. Colliex, they appear to be alive to many of the points that conduce to such stability.

(B) *Lateral stability.*—In the Wright machine the lateral stability is under the direct control of the aëronaut. The two "wings" of the aërofoil are given a twist by straining the structure by means of wires arranged diagonally in the rear panels of the two end bays on either hand. This causes the wings to meet the air at different angles of incidence, and so any desired turning moment about the axis of flight—within certain limits—is at command. This mechanism is employed to neutralise the influence of wind gusts, and to correct the position of the machine should it acquire an undesirable list. It is also utilised to prevent the machine canting too much when turning; and to facilitate its employment in this respect, the rudder aft and the twisting of the wings are operated by one lever, the motion to the right and left being utilised to put tension on the diagonal wires one way or the other, and the movement forward and backward works the rudder.

It is desirable to correct a false impression that is current on the action of the wing twist. It has been supposed by some that it is used to give the cant required by the machine when turning, but such is not the case. If the rudder is used, the machine almost immediately gets a cant owing to the greater pressure on the wing that in turning is moving faster through the air, and this cant becomes, if unchecked, far too severe. The twist is then used to check the cant, the wing on the outer circle—that is, farthest from the centre of curvature—being "feathered," the inner one having its angle of incidence increased.

(A certain patentee sent the author a specification of his invention in which a rudder was carefully arranged to act spirally to give a cant in the direction of the banking—that is, the direction in which the turning moment is already excessive. He might be well advised to take out another patent for the same device, arranged to act in exactly the opposite way.)

In the Voisin machine no hand adjustment is provided to enable the aëronaut to control the lateral stability; hence in this case it is definitely automatic. The Voisin machine is steered by means of a vertical rudder arranged between the fixed tail members, and there is apparently no special mechanism to prevent the over-canting; consequently, Farman in his flights commonly turns in a leisurely manner, employing a circle of considerable radius, whereas Wright may often be seen to perform sensational evolutions, turning with his wings canted to nearly 30 deg. on a radius of perhaps not more than 60 or 70 yards.

It is of interest to note that Farman has recently had fitted to his machine some adjustable flaps to give in effect the wing twist employed by Wright; presumably this is to facilitate turning, for the flight of the machine does not suggest that they are otherwise wanted. The lateral stability leaves little to be desired.

Summarising the comparison from the aërodonetic standpoint, the author is inclined to think that the Voisin machine has the advantage, as containing more of the features that will be embodied in the flying machine of the future. Mr. Wright's contention that it only requires a big enough puff of wind to upset a machine that depends upon its own inherent stability is certainly true, but probably the same is equally true of the hand-controlled machine. There is a limit to the extent of the control that can be exercised, and with hand control we have, too, the possible failure of the human machine. The fact is that the secret of stability is contained in the one word *velocity*, and until it is possible to attain higher speeds of flight we cannot hope to see the flying machine in everyday use.

There is one other point of comparison that, if space permitted, the author would like to make. As it is, a few words must suffice.

The constructional methods employed by Wright and Voisin present a striking contrast. The Wright machine is astonishing in its simplicity—not to say in its apparent crudity of detail—it is almost a matter of surprise that it holds together. The Voisin machine has at least some pretensions to be considered an engineering job.

Mr. Wright defends his methods by asking what would be said by an engineer to the rigging of a sailing vessel if shown to him for the first time, and, to some extent, the analogy is a good reply to the objection; still, the author feels—perhaps wrongly—that there is a considerable amount of the Wright "mechanical detail" that might be revised with advantage, at least before the machine is placed in the hands of the private user. However, "the proof of the pudding is in the eating," and in spite of the rudimentary character and aggressive simplicity of the constructional detail of the Wright machine, it appears not to come to pieces, but continues to fly day after day without showing any signs of weakness or disintegration.

On the question of the motor and transmission mechanism we tread on difficult ground, for the Voisin system of metal propeller keyed direct to the crank shaft, and so immeasurably superior from the purely mechanical standpoint to the chain drive and wooden propellers of Wright, that comparison is unnecessary. Since, however, the simple and direct arrangement adopted by M. M. Voisin is paid for at the price of about a 15 per cent. tax on the transmitted horse-power, the question is evidently one of the balance of advantages and disadvantages that are of entirely different kinds. The author has reasons for supposing that if, in the machine of the future, the geared propeller survives—for it is essentially the use of gearing in the Wright machine that permits the better proportions of propeller to be used—it will be in the form of a propeller or propellers centrally situated, thus resembling the Voisin arrangement rather than in the distribution of propellers such as at present employed by the Brothers Wright. The simplicity of the direct drive may, however, alone be sufficient to outweigh any economic advantages that gearing may possess.

I personally consider the Wright disposition of propellers to be a source of danger. If a torque is applied to an aërodrome about a vertical axis, rotation about this axis at once begins, and, the outer wing travelling through the air faster than the inner, experiences a greater lifting reaction, and if the torque is sufficient the machine is very soon, in nautical phraseology, on its "beam ends." It is evident that if one of the propellers fail from the fracture of a chain or other cause, unless the motor be instantly stopped, the whole power of the motor, and therefore the whole thrust, will be transmitted through the other propeller, causing a torque about a vertical axis that must be overwhelming. If the motor is promptly stopped, then much will depend whether the propeller that has failed is scotched or free. If it has jambed, then it will probably balance by its drag the other propeller, which is either stopped also, or is driving the motor against its internal friction; if, on the contrary, it is free, then the drag of the other propeller will be unbalanced, and there is a serious torque in the opposite sense to that which would have existed if the motor had still been running. Whether Mr. Wright can, in the latter case, by wing twisting and other contortions, save himself from destruction I do not know. It is said that a short time ago a chain actually broke in flight, and the machine safely landed; the altitude when the accident ocurred was stated to be only 4 m. or 5 m., so that Mr. Wright did not have a fair chance of exhibiting his resources. It is to be hoped that he will not have such a mishap at a greater altitude.

[1] "Aërial Flight," Vol. II., Aerodonetics, Chapter V. and VI,

CATALOGUES.

THE INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS COMPANY, Limited, Silvertown, London.—This company has sent us a well-got-up little pamphlet dealing with mosaic india-rubber tiling. This tiling is specially adapted for use on board ships, yachts, in banks, insurance offices, churches, hospitals, railway cars, and other public buildings. Coloured illustrations are given which convey some idea of the artistic possibilities which this new form of flooring presents.

BROWNLIE AND MURRAY, Limited, Possil Ironworks, Glasgow.—A revised catalogue has been sent to us by this company. The illustrations show the many uses to which iron and steel may be put with advantage in buildings of all descriptions. The book also contains much useful information on structural steel work. The various tables giving strengths, &c., of material, we are told, have been carefully prepared. Steel and iron window sashes, among numerous other things, are dealt with, which, we understand, can be made to almost any shape to suit clients' requirements.

MORRIS-HAWKINS, Limited, 75B, Queen Victoria-street, E.C.—This company has sent us a copy of its latest catalogue of direct and alternating current dynamos and motors. A complete description is given of these machines, and the various parts are illustrated separately. Tables are also included giving prices for protected and enclosed ventilated c.c. motors, also enclosed motors and variable speed motors. These tables give prices of motors for voltages ranging from 100 to 500. Motors are also dealt with having reduction gearing, and the latter part of the catalogue deals with induction motors, dynamos, motor starters, &c. Full particulars and prices are given in every case.

THE NORTH BRITISH LIFTING AND MOVING APPLIANCE COMPANY, Limited, 56 and 58, Robertson-street, Glasgow.—This is a well-bound catalogue dealing with various kinds of lifting gear, including hand pulley blocks, power pulley blocks, hand hoists, trolleys rope blocks, lifting jacks, hoisting crabs, hand hoists, friction hoists, steam winches, portable steam hoisting engines, cranes, runways of various types, wire and other ropes, wire rope reels, winches, nippers, and various other kinds of fittings. The last part of the book is devoted to barrows, trucks, and wagons. There are over 200 pages, and numerous illustrations.

THE BRITISH WESTINGHOUSE COMPANY, Trafford Park, Manchester.—A well bound and extensive catalogue has reached us from this company. It deals with electric lighting accessories, ammeters and voltmeters, auto-starters, auto-transformers and balancers, bells, indicators and batteries, cables and wires, controllers, crane switchboard panels, electricity meters, fans, fuses, fuse-boxes, &c., field discharge switches, instruments, lightning arresters and choke coils, liquid starters and controllers, motors, motor control apparatus, radiators, stove radiators, stoves, resistances, switches, switchboards, telephones, transformers, &c. The catalogue is well illustrated and prices are given throughout.

HANS RENOLD, Limited, Manchester.—This is a treatise on the driving chains and chain drives produced at these well-known works. The case for power transmission by means of chains, as compared with other means, is very well set out. The book is divided into three main parts:—Part I. deals with the three types of chains most generally used, the forms of sprocket teeth, and the principles of chain gearing, the types of sprockets, tools for making them, and appliances necessary for joining chains. Part II. shows the chain transmissions used in Renold's new works, and contains the results of the maker's experience which will be found useful to engineers generally. In Part III. particulars of a number of installations in other works are given, together with illustrations. As the book is intended to be educational rather than commercial, sizes and prices are not included, but these can be had separately from the makers. The book is produced with the best taste, and will be found worthy of serious attention on the part of engineers and manufacturers who are interested in the transmission of power. Copies will be sent to those of our readers who care to apply for them.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Pig Iron.

PIG iron has maintained its strength, and smelters have sufficient contracts to keep them well employed for some time ahead. It is regarded as a good sign that makers have practically no stocks, and it is reported that in some cases sales have been made for the first three months of the New Year at present prices. Generally, however, there is a disinclination to book forward at prevailing quotations except for small quantities. The demand has of late been such as to enable sellers to command the market rates, and these are likely to remain unaltered until next quarter. If the present hopes of an industrial awakening are then fulfilled, there will be an upward movement. Prices are:—Forge pig iron: Staffordshire, common, 46s.; part-mine, 48s. to 49s. 6d.; best all-mine, 80s. to 81s.; cold blast, 110s.; Northamptonshire, 46s. to 47s.; Derbyshire, 48s. 6d. to 49s. 6d.; North Staffordshire, 49s. to 50s. Pending the arrival of January, sales this week have been of a nominal sort only, and to-day's—Thursday's—meeting in Birmingham was more a matter of marking time than anything more serious.

Finished Iron Business.

As the holidays approach there is no increase in the orders for finished iron. The bar trade is dragging, and will continue to do so as long as the existing disparity between demand and productive capacity lasts. Marked bars still stand at the £8 basis, and South Staffordshire unmarked bars make £5 17s. 6d. to £6 5s. The standard for North Staffordshire crown bars remains at £6 10s., delivered at ports. Other prices are:—Hoop iron, £6 17s. 6d; gas strip, £6 5s. to £6 7s. 6d.; slit nail rods, £7; rivet iron, £6 15s. to £7. Until next year is entered upon there is not now much to be expected of the manufactured iron trade in any of its branches, and it does not seem likely that many unexecuted contracts of much value will have to be carried over into 1909. From this it will be realised that the probabilities are all in the direction of ironmasters' order books at the mills and forges in this district being closely worked up by the time Christmas is here.

Reported Galvanised Sheet Combination.

The report that we were likely to see a combination of Midland, West of England and Cheshire, and other English galvanised sheet firms with the iron and steel galvanised sheet makers of America has been promptly denied by John Lysaght, Limited, one of the largest makers concerned. Messrs. Lysaght state that the report is "entirely without foundation;" neither is any confirmation of the report obtainable this week from any of the Midland makers. Probably, therefore, there is nothing in it, but it is singular that the report had its origin in a very good source, viz., South Wales, where Messrs. Lysaght's works are themselves situated. The circumstance, however, that the rumour of the combination has had no effect upon the market, as those most concerned admit, is entitled to rank in support of the denial which has been issued. As was intimated in this letter last week, it is perfectly understood that by their becoming purchasers of American half-product steel, a definite arrangement has existed between the British manufacturers and those of the United States for some time past concerning the restriction of competition in Western export markets, and probably this arrangement will be prolonged into 1909. Galvanised sheet prices remain at the Association figure of £12 10s. for 24 w.g., and the surroundings favour the expectation of a rise pretty early next year. If the shipping trade was to expand an early advance would be certain to occur.

The Spelter Market.

Spelter, which is such an important raw material for the galvanised sheet makers, has recently proved much stronger in price, although the market has shown some irregularity. There has been a keen demand from dealers for delivery in 1909 at a premium of 10s. to 12s. 6d. per ton over spot prices, while consumers have purchased pretty freely, and the accumulations in dealers' hands have become quite moderate. Despite a lull in the demand for next year, which reduced the premium mentioned by half, near stuffs have further hardened to about £21 10s. per ton, as metal is now sparingly offered since the cold weather has impeded export from Germany. Part of the quantity "hung up," estimated at some 1500 tons, may be freed with milder weather, but some scarcity may arise in this country in the next few months, and this, with the consuming trades more active, may occasion higher selling prices. Consumption this year has probably fallen behind last year, but it now appears to be again increasing. The European output, too, is falling off, so that on various grounds the market seems now healthier. The present price is about £3 10s. per ton over the lowest this year, and £8 below the record paid during the last trade "boom."

Raw and Rolled Steel.

The demand in the raw steel trade is tame, and prices of native sorts are badly overshadowed by the continental and American importations. Raw steel sheet bars are quoted at £4 12s. 6d. to £4 15s., mild finished bars at £6 7s. 6d. to £6 17s. 6d., girder plates at £6 to £6 2s. 6d., boiler plates at £7, joists at £5 15s. to £6 5s., and angles at £5 15s. to £5 17s. 6d. The demand for rolled steel shows no material change. Any material improvement for this district must depend mainly upon increased activity in the constructive engineering trades, the railway wagon building trades, and the steam boiler industry.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Wednesday.

Not much Business in Pig Iron.

THE attendance on the Iron 'Change on Tuesday was rather better than usual. Stocktaking, and the fact that local trade is far from brisk, restricts business, and we do not anticipate any great change until after the New Year. While consumers are still only buying for current requirements, merchants are rather disinclined to commit themselves far forward, although we hear of good sales for textile machinery making, which is the best employed branch at the present time. Lincolnshire foundry iron is held for full rates, while some improvement is to be noted in Middlesbrough brands. Derbyshire, on the other hand, is very irregular, and very low prices are being quoted in some cases, so that demand may be stimulated to keep pace with production. Scotch and hematite are also weak. Forge iron showed little change.

Finished Iron and Steel.

There was only a moderate demand for finished iron at late rates, but steel was in fair inquiry, and the outlook was reported better. Steel bars have recovered about 2s. 6d. per ton, local, and this notwithstanding keen competition from Scotland; indeed, certain well-known English firms decline to quote under

£6 5s., except for quantity. In billets there is also a better feeling for both British and foreign.

Copper, &c.

Ingots were a shade lower, but manufactured was unchanged and business slow. Sheet lead: quiet. Tin: English ingots unchanged.

Quotations.

Lincolnshire No. 3 foundry, 53s. to 53s. 6d.; Staffordshire, 53s.; Derbyshire, 52s. to 52s. 6d.; Northamptonshire, 54s. 6d.; Middlesbrough, open brands, 57s. 4d. to 57s. 10d. Scotch: Gartsherrie, 59s. to 59s. 6d.; Glengarnock, 58s. 6d. to 59s.; Eglinton, 57s. 6d.; Dalmellington, 57s. 6d. to 58s., delivered Manchester. West Coast hematite, 58s. 6d.; East Coast ditto, 57s. 6d., both f.o.t. Scotch delivered Heysham: Gartsherrie, 57s. to 57s. 6d.; Glengarnock, 56s. 6d. to 57s.; Eglinton, 55s. 6d.; Dalmellington, 55s. 6d. to 56s. Delivered Preston: Gartsherrie, 58s. to 58s. 6d.; Glengarnock, 57s. 6d. to 58s.; Eglinton, 56s. 6d.; Dalmellington, 56s. 6d. to 57s. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 15s. to £8. Steel: Bars, £6 2s. 6d. to £6 5s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler plates, £7 7s. 6d.; plates for tank, girder, and bridge work, £6 5s. to £6 7s. 6d.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto, £4 5s. to £4 7s. 6d.; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £77; tough ingot, £64; best selected, £66 per ton; copper tubes, 9¼d.; brass tubes, 7¾d.; condenser, 8¾d.; rolled brass, 6¾d.; brass wire, 7d.; brass turning rods, 6¾d.; yellow metal, 6¼d. to 6¾d. per lb. Sheet lead, £16 to £16 5s. per ton. English tin ingots, £132 per ton.

The Lancashire Coal Trade.

The attendance on the Manchester Coal Exchange was quite up to the average. Slack and industrial fuel were gener lly slow, but the demand for house coal was rather better. In shipping and bunkering coal there was little doing. Quotations:—Best Lancashire coal for domestic purposes, 14s. 2d. to 15s. 8d; seconds, 12s. 2d. to 13s. 2d.; common, 9s. 2d. to 11s. 2d.; best burgy, 10s. 6d. to 11s. 6d.; round furnace coal, 11s. to 11s. 6d.; best slack, 9s. to 10s.; medium, 8s. 6d. to 8s. 9d.; common, 7s. 6d. to 8s., at the pit; coal for bunkering purposes, screened, 11s. to 11s. 6d.; unscreened, 10s. 6d., delivered Manchester Ship Canal.

BARROW-IN-FURNESS, Thursday.

Hematites.

The hematite iron trade has not been in a worse position for many years past. There is very little demand at present, and makers are producing less iron than usual, and have, in fact, very few orders on hand. Hopes are entertained that the iron trade will improve in response to a better demand for steel, and that to some extent in consequence of a prospective increase in the activity of the shipbuilding and engineering trades, as to which there is almost a certainty of early realisation. There is not, however, any hope of a sudden improvement in the other usual sources of demand for iron. Makers hold very few orders, and much of their business is confined to small parcels for prompt delivery. There is not much forward business doing. Stocks are very low indeed, as makers are only holding some 30,000 to 35,000 tons, and in warrant stores the iron held only bulks at 6500 tons. Prices show no change. Mixed Bessemer numbers are at 58s. 6d. net f.o.b., and warrant iron is at 57s. 9d. net cash sellers, with no business doing of a speculative nature. Indeed, the business being done at the moment is entirely of a consumptive character. Iron ore is easy at 9s. 9d. to 10s. net at mines for good ordinary sorts. Three cargoes of foreign ores are being imported at Barrow this week, but this is mainly for use in the production of ferromanganese and spiegeleisen, the demand for which is moderately maintained.

Steel.

The demand for all classes of steel is very quiet. In railway material very little is being done, the orders recently booked being only sufficient for about half employment for two of the firms in the district, while the mills at Barrow are idle, and according to the latest report are likely to remain so for some month or two longer at least. Nothing has been done in shipbuilding material for some time by producers in this district, but as the demand is likely to improve, it is believed the plate mills, the merchant mills, and the heavy steel foundries will soon be busy.

Shipbuilding and Engineering.

The rumour is current in Barrow this week that Vickers, Sons and Maxim have secured the order for six Spanish battleships of the Lord Nelson type improved, but it requires official confirmation. It is certainly true that shipbuilding prospects are better than they have been, and it is believed this exceptional order will ultimately come to the Vickers firm, if it has not already been secured.

Shipping and Coal.

The exports of iron and steel from West Coast ports last week amounted to 11,858 tons—iron 6903 tons, and steel 4955 tons—as against 14,422 tons in the corresponding week of last year, a decrease of 2564 tons. For the year to date the shipments aggregate at 480,370 tons, against 797,435 tons for the corresponding period of last year, a decrease of 317,065 tons. Coal and coke are cheaper.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Hull Coal Traffic.

As was anticipated, the return of the Hull Chamber of Commerce exhibits a heavy decline in the coal trade with Hull during November, as compared with the corresponding month of 1907. The weight forwarded was 429,184 tons, as against 578,208 tons in November of last year. For the eleven months the total is 5,431,936 tons, compared with 6,059,088 tons. The decrease for the month is, therefore, 149,024 tons, and for the eleven months, 627,152 tons. Of the contributing collieries, Denaby and Cadeby Main, as usual, head the list with 44,632 tons for the month, against 44,440 tons; Dalton Main comes next with 32,248 tons, compared with 11,600 tons; and Aldwarke Main third with 21,128 tons, as against 27,144 tons.

Foreign and Coastwise Trade.

The exports from Hull to foreign markets show a total for the month of 266,202 tons, against 301,300 tons for November of last year. For the eleven months, 2,692,203 tons against 3,151,482 tons last year. The decrease in exports on the month is largely due to the falling off in trade with Holland and Germany, the former market taking 28,080 tons and the latter 43,752 tons, which figures compare with 42,965 tons and 68,229 tons respectively for November of last year. For the eleven months, the decrease with Holland is striking—338,509 tons, compared with a total of 749,256 tons for the eleven months of 1907. The principal market last month was Sweden, which took 47,961 tons, but this total compares with 62,033 tons for November of last year; for the eleven months, however, there is an increase, 385,469 tons, compared with 377,025 tons last year. North Russia, with 35,688 tons, compares with 42,245 tons for November of last year; but there is a large increase on the eleven months—639,444 tons, against 457,957 tons last year. Considerable increases on the month are shown with South America and Austria, the totals being 27,564 tons and 18,978 tons, compared with 11,695 tons and 827 tons respectively. The coastwise export traffic last month amounted to 76,269 tons, which is mainly made up of 50,312 tons forwarded to London, 10,210 tons to Southampton, 3800 tons to Plymouth, and 2940 tons to Woolwich. For the eleven months the coastwise trade amounted to 817,414 tons.

House, Steam, and Gas Coal.

Domestic fuel, owing to the approach of Christmas and the holidays, is kept a little brisker, but the increased demand is not sufficient to affect quotations. A good deal of business, indeed, has been delayed through expectations that the prices would actually go lower instead of higher. Of course, these expectations have not been realised, as quotations have been maintained, and the tendency at the time of writing is rather firmer than otherwise. Best Barnsley, 11s. 6d. to 12s. 6d. per ton; secondary sorts, from 10s. to 11s. per ton at pits. Steam coal continues as previously reported, the export trade steadily declining. The latest return from the Humber ports shows that for the week ended December 8th the exports from Hull amounted to 39,663 tons, compared with 75,671 tons in the corresponding week of last year; from Grimsby, for the week ended December 11th, the exports totalled 28,544 tons, compared with 45,229 tons for the similar period of last year. Coal for shipment, 9s. to 9s. 6d. per ton at the pits. The Midland Railway Company is extending its contracts for locomotive fuel at considerably lower prices than those prevailing at the early part of the year. The gas companies and corporation gas departments are pressing for supplies, owing to the coming shutting down of pits for the holidays and the general requirements of Christmas and the New Year, the social necessities of the period adding considerably to the consumption. Gas coal contracts are not made at this season, but usually during the summer months, from 1st April to 31st August.

Small Coal and Coke.

Conditions unchanged. A good business is being done in best quality slacks, especially hard slacks, due to the shorter time worked; the cheaper qualities are more abundant. Small coal for Lancashire cotton mills quoted at 4s 6d. to 5s. 6d. per ton, with "spot" sales somewhat lower than these figures. Coke in fair request, best washed making 10s. 6d. to 10s. 9d. per ton; unwashed, 10s. 3d. to 10s. 6d. per ton.

Iron.

The moderate improvement in buying of pig iron noted last week is maintained. We hear of several contracts for fair amounts having been made within the last few days for delivery in the first quarter of the New Year. The Lincolnshire Ironmasters' Association held their usual meeting last Friday, but made no alteration in their official quotations. No contracts of any magnitude are at present in hand for hematites, but makers are able to sell their reduced make for immediate consumption. This enables a reasonable price to be maintained, and there is an absence of speculation. Quotations, in all cases net, delivered in Sheffield or Rotherham, are as follow:—Hematites, West Coast, 68s. to 70s. per ton; East Coast, 63s. to 65s. per ton; Lincolnshire, No. 3 foundry, 49s. per ton; No. 4 foundry, 48s. per ton; No. 4 forge, 47s. per ton; No. 5 forge, mottled and white, 47s. per ton; basic, 48s. per ton. The premium of 2s. per ton on Lincolnshire official quotations is still insisted upon. Derbyshire, No. 3 foundry, 50s. per ton; No. 4 forge, 49s. per ton.

Bars, Sheets, and Billets.

There is no change to report in the finished iron trade. The South Yorkshire Bar Iron Association, at their recent meeting, left the bar iron quotation unaltered at £6 10s. per ton. Sheets are quoted at £8 to £8 10s. per ton; Bessemer billets, £7 per ton; Siemens ditto, £7 10s. per ton.

The Heavy Industries.

The Government orders were allotted a little time ago, but the firms receiving them are not in possession of the particulars necessary to get to work on them. The first effect of these particulars would, of course, be in the steel-producing departments, and afterwards in the various finishing departments. All firms engaged in marine work are very much in want of fresh orders, and the particulars referred to would be exceedingly welcome. In certain departments of our large works the activity at present being experienced is rather in anticipation of more prolonged holidays than would be the case under normal conditions. At this time of the year inquiries are sent out by railway companies for some portion of their supplies, but these generally do not take effect until the beginning of the new year. On the present occasion the demand is not likely to be in any great volume, as the companies are still pursuing the policy of retrenchment, and only ordering what is adequate to meet current requirements. There is another consideration. The various amalgamation schemes are rendering unnecessary the duplicate stocks that companies have been accustomed to keep for their independent use, as the amalgamation enables them to assist each other in cases of emergency. All this, however, tends to the reduction of work to the producers of railway material.

The Lighter Industries: Government Contracts.

The Admiralty have issued specifications for their annual supplies of tools for use in the dockyards, including light and heavy edge tools, shipbuilders', engineers', joiners', and wood working tools, as well as vices and anvils. The War-office invite tenders for 120,000 table knives, 100,000 table forks, 73,000 unplated table spoons, and 63,000 razors in cases.

Sheffield Chamber of Commerce.

The Council of this Chamber had before them on the 10th inst. a letter from the Town Clerk, asking the views of the Chamber on the question of inviting foreign manufacturers—who might be coming to England to manufacture patented articles in order to preserve their rights under the Patents Act—to establish their works in Sheffield. The Council were in favour of invitations being cordially given by the Corporation. From the Colonial-office was received a letter stating that the protest of the Chamber against the higher licence taxes that are being imposed upon commercial travellers throughout Cape Colony had been forwarded to the Governor of that Colony. The Council also decided to send to Lord Lansdowne a strong resolution of protest against the Coal Mines Eight Hours Bill.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

QUITE a spurt in the demand for Cleveland pig iron has been experienced this week, and a brisk business has been done, more, indeed, than in any week for some months. Consumers have come forward freely, and it is more they than the speculators who have brought about the change. This is partly shown by the fact that the improved prices are not confined to those for No. 3 alone, but all the other qualities of pig iron have advanced in value, and more than that the quotations for forward deliveries have moved up likewise. With the holidays so near such an accession of business was not expected this month, but evidently there is more confidence being developed. On Tuesday particularly there was quite a rush to buy iron, and some of the producers on that day alone added orders to the extent of 10,000 tons to their books. It is a satisfactory sign to see that there is a contango of no less than 7½d per ton in the three months' price of Cleveland warrants, whereas most of the year the forward prices have been below the prompt. It may thus be inferred that the sanguine tone which has sprung up is justifiable. Inquiries have been numerous this week, and some have been from the United States, and these latter have doubtless done something to strengthen the market. Consumers are also showing a disposition to buy for delivery over the whole of next year, but makers will not commit themselves to deliveries much ahead, and especially as buyers are not prepared to give much above prompt prices for forward delivery. A good deal of No. 3 Cleveland G.M.B. pig iron has been sold this week for early f.o.b. delivery at rates varying from 48s. 6d. to 49s., and the price has been put up to 49s. 3d., and this in face of the rapid increase of stock in Connal's store and the poor shipments. But these unsatisfactory features do not apparently attract much attention, and are counterbalanced by better influences. No. 1 pig iron is advanced to 51s. 6d., No. 4 foundry to 48s. 3d., No. 4 forge to 47s. 3d., and mottled and white to 46s. 9d. per ton, all for early delivery, with 6d. more for delivery over next quarter. It is generally believed that the worst of the depression has now been experienced, and certainly the position and prospects are more favourable than they have been for several months.

Hematite Pig Iron.

While such a marked change for the better has appeared in the business in ordinary Cleveland pig iron, the hematite iron demand and prices are altogether stationary. Scarcely any consumers are buying just now, and if good sales had not been made for forward delivery some weeks ago, the producers would have been badly situated at the present time. Buyers are holding off, though there does not seem to be much probability that prices will be any lower. A short time ago consumers were, in some instances, offering to buy for delivery over the whole of next year, and that pointed to the fact that they did not look for reduced quotations. Makers have no stocks, nor is there any hematite iron in the public stores, for makers will not produce more than the market requires. They have now an objection to accumulating stocks, and, in consequence of this policy, their prices are much steadier than those of Cleveland iron, which change almost every day, being in great part regulated by what is being done in warrants, and thus are influenced a good deal by purely speculative business. Most of the furnaces that have been blown out since the boom ended were those producing hematite iron. Makers now quote 56s. per ton for early f.o.b. delivery of mixed numbers East Coast hematite pig iron, and 56s. 6d. for first quarter next year, but second hands, who over-bought in September and October, when there was a spurt in the demand for hematite, are selling small lots for immediate delivery at 55s. 6d.

Iron Ore.

The supply of ironstone from the Cleveland mines continues short of the requirements, and considerable quantities of Northamptonshire ironstone have to be obtained to make ordinary Cleveland pig iron. Messrs. Pease and Partners have opened a mine under Easby Moor, which is to be known as the Monument mine, and ironmasters are prospecting in various parts of the district for further supplies of the stone. Scarcely any contracts for foreign iron ore have been entered into lately, and consumers are in no hurry to buy yet, as they have plenty of contracts running, and in some cases heavy stocks. The price of Rubio ore remains nominally at 15s. 9d. per ton c.i.f., Middlesbrough. Ore freights are almost the lowest ever recorded, 3s. 9d. per ton being taken from Bilbao to the Tees. Gellivare ores range from 17s. to 19s. per ton, delivered at North-East Coast ports.

Pig Iron Stocks.

Attention is directed to the somewhat rapid rate at which the stock of Cleveland pig iron in Connal's stores is accumulating, but that nevertheless is not having a detrimental influence on the market, being counterbalanced by some good features. The stock on 16th was 115,184 tons, an increase of 9164 tons this month, and of 67,205 tons since the tonnage held began to increase in the early part of July last. There is now a heavier stock than has been known since November of last year, and all the stock that Connal's hold in this district is No. 3 Cleveland G.M.B. pig iron, except 985 tons.

Shipments of Pig Iron.

The exports of pig iron from the Cleveland district promised to be good this month, but they are comparatively small, and this half-year's exports cannot be otherwise than the worst that have been reported since 1905. They are worse to oversea destinations than have been known for a very long time, and prospects are not favourable for their being better for at least two months to come. This month's exports to 16th reached 48,123 tons, as compared with 56,682 tons last month; 47,441 tons in December, 1907; and 65,029 tons in December, 1906, all to 16th.

Manufactured Iron and Steel.

The dulness is slowly but steadily giving place to improvement in several branches of the manufactured iron and steel industries, and generally producers take a more encouraging view of their position and prospects. This is more particularly noticeable in the rail department, which, however, has not been so badly affected by the depression as some of the other branches. The plate and angle manufacturers are better off than they were, but the improvement has not been so great as it was expected it would be after the strikes in the shipbuilding industry terminated. In no branch of the finished iron and steel industries, though trade is better, has business improved enough to justify the producers advancing any of the prices, and they have been stationary for some considerable time. Steel ship plates are at £6; iron ship plates, at £6 7s. 6d.; steel ship angles, at £5 12s. 6d.; iron ship angles, at £7; packing iron and steel, at £5 10s.; steel bars, at £6 5s.; iron bars, at £7; steel hoops, at £6 10s.; steel strip, at £6 7s. 6d.; steel sheets (singles), at £7 10s., all less 2½ per cent. f.o.t. Galvanised and corrugated sheets, 24 gauge, in bundles, are at £12 10s. per ton, less 4 per cent. f.o.b. Heavy steel rails are at £5 10s. per ton net f.o.b.; and cast iron chairs, at £3 10s., net f.o.b.

Shipbuilding.

While there has lately been some improvement in shipbuilding, it cannot be said that the prospects are good, nor are they likely to be as long as the rates of freight are so low and unprofitable. In some trades the rates are about the lowest ever known, notably in the iron ore trade, where the shipowners are keen to accept such a ridiculously low figure as 3s. 9d. per ton, Bilbao to the Tees. There are far too many steamers competing, though all our rivers are congested with laid-up tonnage; in fact, in some there is no further accommodation available. Not since 1886 has there been so many laid-up vessels, and it is surprising that there are any orders forthcoming for new steamers. The unprecedentedly low figures which the builders are willing to accept, however, attract some owners. The Teesside builders have appreciably improved their position, but on the Tyne and Wear the trade is almost as bad as ever. There can hardly be any real improvement in have made a proposal to set a limit to the production of new shipbuilding as long as freights keep so bad. The Germans tonnage.

Coal and Coke.

The coal market is somewhat busier, and the demand for steam qualities is better than is usual at this period of the year, but it is, of course, in a much less satisfactory condition than had to be reported half a year ago, when there was quite a boom in steam coal. The present price of best steam coal is 10s. 9d. per ton f.o.b. for prompt delivery. The business in gas coal is so good that the owners are making a decided stand against any further reduction in the prices; a large proportion of their next year's out-

put is already sold. Heavy speculative sales are reported to have been made abroad, especially in Italy, and these have yet to be covered by purchases from the collieries. The position of the Durham colliery owners is thus satisfactory, and they will not sell under 10s. per ton for next year. Considerable contracts have been refused at 9s. 6d. to 9s. 9d. Bunker coal is in quiet request at 8s. 9d. per ton. Foundry coke is quoted at 17s. 6d. f.o.b., and furnace coke at 16s. per ton delivered equal to Middlesbrough.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Business Outlook.

THE feeling in business circles is somewhat more cheerful, but it is apparently founded on anticipation rather than on present experience. In several connections there has been a little more done in view of the near approach of the holidays, but trade and business are generally about as dull as ever. At one or two of the shipyards the workmen who have been able to find employment are now placed on short time, and there is very little diminution in the number of the unemployed.

The Pig Iron Market.

A steadier feeling has ruled in the pig iron warrant market, and prices have been rather better. The advices from America have been accepted as somewhat more encouraging, and the market has also been favourably influenced by reports of considerable purchases of Cleveland iron for Italy, to be delivered over a great part of next year. Business has been done in Cleveland warrants from 48s. to 48s. 11½d. cash, 48s. 9d. to 49s. 1½d. for delivery in one month, and 49s. 3d. to 49s. 6d. three months

Scotch Makers' Iron.

The demand for Scotch makers' pig iron has for the most part been confined to small lots for immediate use. Prices are generally steady. G.M.B., No. 1, is quoted at Glasgow 55s. 6d.; No. 3, 53s. 6d.; Carnbroe, No. 1, 57s.; No. 3, 54s.; Clyde, No. 1, 59s. 6d.; No. 3, 54s. 6d.; Gartsherrie, No. 1, 60s.; No. 3, 55s; Summerlee, No. 1, 62s.; No. 3, 57s.; Calder, No. 1, 61s.; No. 3, 56s.; Langloan, No. 1, 65s.; No. 3, 60s.; Coltness, No. 1, 89s.; No. 3, 59s. 6d.; Glengarnock, at Ardrossan, No. 1, 62s.; No. 3, 57s.; Eglinton, at Ardrossan or Troon, No. 1, 55s. 6d.; No. 3, 53s. 6d.; Dalmellington, at Ayr, No. 1, 58s. 6d.; No. 3, 53s. 6d.; Shotts, at Leith, No. 1, 61s. 6d.; No. 3, 56s. 6d.; Carron, at Grangemouth, No. 1, 63s. 6d.; No. 3, 57s. 6d. per ton. The output of pig iron so far has been well maintained. There are 77 furnaces in blast, compared with 87 at this time last year, and of the total 41 are making hematite and 36 ordinary pig iron. The stock of pig iron in the public stores here and in the North of England shows an increase of about 25,000 tons compared with the quantity held at the beginning of the year.

Exports and Imports of Pig Iron.

The shipments of pig iron from Scottish ports in the past week have been 6589 tons, against 5187 in the corresponding week. There was despatched to Italy 1415 tons; United States, 725; South America, 622; Australia, 355; Canada, 15; India, 130; France, 10; Germany, 25; Holland, 230; Belgium, 250; other countries, 250; the coastwise shipments being 2562 tons, compared with 3197 in the corresponding week of last year. The arrivals at Grangemouth of pig iron from Cleveland and district were 10,771 tons, against 11,806 in the same week of last year, showing a decrease of 1035 tons. The total imports for the year to date are 452,070 tons, being 57,315 tons less than in 1907.

Hematite Iron and Steel.

During the last six days eleven steamers arrived in the Clyde with cargoes of hematite ore, two of these being from England, and the rest from foreign ports. The current rate of freight from Bilbao to the Clyde is 4s. per ton. The output of hematite pig iron is larger than at any former time, and it is believed that a considerable quantity of it is going into private stores in anticipation of future wants. In the steel trade there has been no improvement. Orders are scarce, and inadequate to the capacity of the works, and competition has been increasing for such miscellaneous material as has been coming into the market.

Finished Iron and Engineering.

The finished iron department has been very quiet, and on some days lately it has not been possible to keep machinery in operation. There is a want of employment in many branches of the engineering trade. Marine engineers are anticipating an improvement shortly in connection with shipbuilding orders placed some time ago. Prospects are improving in the locomotive engineering trade, and an order for twenty engines for the East India Railway Company, just secured after keen competition by the North British Locomotive Company, is hailed with satisfaction.

The Coal Trade.

The shipping branch of the coal trade continues active, the clearances at the ports comparing well with this time last year Current demand for export is good, but supplies are more than equal to all requirements. At Glasgow the f.o.b. prices are, for house coal, 9s. 6d. to 10s.; steam, 9s. 6d. to 10s. 3d.; and splint, 10s. to 10s. 6d. per ton. The inland trade in household coal is quiet, owing to fine weather, and the demand for manufacturing purposes continues inactive. The three principal railway companies—Caledonian, Glasgow and South-Western, and North British—are now issuing to those concerned the regulations under which it is intended to work the mineral traffic from 1st February next, when the system of demurrage charges is to come into operation. It is stated that these rules are the same as those under which the railway employés have been accustomed to work the traffic, only that they are now to be put into the hands of traders. On the part of the companies it is notified that every endeavour will be made to regulate supplies of wagons in accordance with the actual requirements of traders. In future, however, verbal orders for wagons will not receive attention, but the companies must receive written orders for them. By this means, of course, the companies will be in a position to keep a register of the wagons, and also to check the time they are in use, and they will also have incontestible evidence on which demurrage rates can be based. Some of the coal shippers are of opinion that an enforcement of the regulations will facilitate traffic, but not a few traders and others interested are apprehensive that difficulty may arise in carrying them into effect with impartiality.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Eight Hours Bill.

THE remarks made in this column last week upon this objectionable measure have been confirmed in many quarters. All commercial bodies are unanimous in their protest, and regard the Government as lacking in their best consideration for the interests of the country at large by their ignoring the views of the men who should know better than any others the real needs of the country. A working collier, experienced and thoughtful, said, personally, "It will be the first step to send up coal to 60s. per ton. The first bad sign will be friction between the hauliers and the colliers," adding, "There is a growing discontent amongst the colliers. They are getting tired, too, of the constant levies through ill-considered strikes, and, if these increase, the view will be strengthened that the old rule was far more satisfactory than that of the Federation."

Last Week's Coal Trade.

Newport had again a heavy coal trade, having despatched 96,617 tons, foreign and coastwise. Swansea despatched close upon 67,000 tons. Port Talbot showed a slight decrease, while Cardiff throughout, though the trade was rather irregular, yet cleared off substantial cargoes daily, rarely falling below 30,000 to 40,000 tons, Monte Video, Port Said, and French ports figuring as usual largely. There is fairly well-based expectation that large clearances will take place prior to, and the week following, the holidays. The output has been large, even though the unwise stoppage at Llwynypia has lessened the total by several thousand tons. The strike may now be considered at an end, but the men will do well to bear in mind the warning given, that as these frequent stoppages affect contracts, owners will be necessitated to take steps for the losses to fall on the right shoulders. They will obtain three weeks' strike pay.

Latest Coal Prices at Cardiff.

THE fluctuations in prices have been small. Best steam coal has on several occasions been close to 15s. per ton, but the bulk of business has been done slightly under, 14s. 6d. and 14s. 9d. being the most prominent. There is not so much animation in the trade as used to be the case before Christmas. Evidently buyers are dubious of the condition of things. Latest prices:—Best large steam, 14s. 6d. to 14s. 9d.; seconds, 13s. 6d. to 14s.; ordinary large steam, 13s. to 13s. 3d.; drys, best, 14s. 6d. to 14s. 9d.; ordinary, 12s. 9d. to 13s.; best Monmouthshire black vein, 13s. to 13s. 3d.; Western Valleys, 12s. 6d. to 13s.; Eastern Valleys, best class, 11s. 9d. to 12s.; other kinds, 11s. to 11s. 6d.; best house coal, 17s. 6d. to 18s.; other kinds, 14s. 6d. to 16s. 6d.; No. 3 Rhondda, 17s. 6d. to 18s.; through, 13s. 9d. to 14s.; smalls, No. 3, 9s. 6d. to 10s.; No. 2 Rhondda, 11s. 9d. to 12s.; through, 9s. to 9s. 6d.; No. 2 smalls, 7s. to 7s. 6d.; best washed nuts, 12s. 6d. to 13s.; seconds, 11s. to 11s. 6d.; peas, 10s. 6d. to 11s.; seconds, 9s. 6d. to 10s.; best small steam coal, 8s. to 8s. 3d.; seconds, 7s. to 7s. 6d.; other smalls, 6s. 3d. to 6s. 9d. Patent fuel, 13s. 6d. to 15s. Coke, 15s. 6d. to 26s., according to kind. Pitwood, 19s. to 19s. 6d. ex ship.

Monmouthshire Coal at Newport.

Best black vein, 13s. 3d. to 13s. 6d.; Western Valleys, 12s. 6d. to 12s. 9d.; Eastern Valleys, 11s. 9d. to 12s. 3d.; other sorts, 11s. 3d. to 11s. 6d.; best smalls, 7s. 3d. to 7s. 6d.; nut coals, best washed, 12s. to 12s. 6d.; house coals, best, 16s. to 16s. 6d.; seconds, 15s. to 15s. 6d.; patent fuel, 14s. 6d. to 15s. 6d.; pitwood, 18s. to 19s.; coke, furnace, 15s. to 16s. net; foundry, 16s. 6d. to 17s. 6d.

Anthracite at Swansea.

Slightly reduced quotations. All kinds are rather slow in demand. Best hand-picked malting, 24s. to 25s.; seconds, 22s. 6d. to 23s. 6d., Swansea, net; Valley, big vein, 21s. 6d. to 22s., less 2½; red vein, 13s. 6d. to 14s., less 2½; machine-made cobbles, 23s. to 24s. net; French nuts, 25s. 6d. to 26s. 6d. net; German, 25s. 6d. to 26s. 6d.; machine-made beans, 18s. 9d. to 19s. 9d. net; peas, 12s. to 13s. net; rubbly culm, 4s. 6d. to 4s. 9d., less 2½; ordinary duff, 2s. to 2s. 6d. net. Other coals:—Steam, 15s. to 15s. 6d.; small, 7s. to 8s.; No. 3 Rhondda, 17s. 6d. to 18s.; patent fuel, 12s. 6d. to 13s., all 2½ per cent. less. The market report is more hopeful, and states that the volume of business transacted was good, and Swansea Valley in strong demand. Red vein slow.

Coal Contracts for Wales.

On 'Change last week one of the leading topics of conversation was a statement made, with some degree of authority, that Germany was in the market for a very large supply of Welsh steam coal, touching closely upon 650,000 tons. This had the effect of influencing the market in some quarters, but the older members recalled the fact that a similarly large order was discussed a year or two before, and then it was discovered that it was a tentative one, more to ascertain the prices prevailing than to lead to business, the result on that occasion being the placing of an order for a small quantity, the bulk remaining in Germany. It is expected that a similar result will be the case this year. Among the likely contracts there are two of importance, that of the Hungarian railways for 75,000 tons, and one of 65,000 tons for the Russian Government. Hungarian was stated this week to be 200,000 tons, extended over two years; large steam. Tenders to be in by December 23rd.

The Railway Fusion.

It is understood that good progress is being made in formulating arrangements and details, but for the present particulars are withheld. Shares are firm.

Iron and Steel.

Those interested in these trades are now inquiring what will be the effect of the Eight Hours Bill, first in hardening and then increasing prices of coal. The leading works have placed their best steel before problematical customers at the lowest price, and with the exception of a few colonial orders the response has been weak. Home railways so far have not indicated their intention to go in for large renewals, and it is not difficult to forecast what will happen if prices of railway material are advanced. Ebbw Vale, with its large interests in the great northern centres, is, under the management of Mr. Mills, as well placed as any works to meet the best requirements of the country, but the note of lament in the tone of correspondence on the subject of tariff reform is almost despairing. Last week Cyfarthfa had little more signs of life exhibited than at an ordinary blacksmith's shop. Steel totalling 2468 tons came to Newport this week from New York; pig iron to Wales from Millom and Grimsby; ore from Bilbao. Dowlais continues fairly active, and is progressing in developments. Latest quotations, Swansea:—Hematite pig, mixed numbers, 57s. 6d. cash and month; Middlesbrough, 48s. 9d. cash, 48s. 11½d. month; Scotch, 54s. 9d. cash and month; Welsh hematite, 61s. 6d. to 62s. 6d. d.d. Only steel quotations are for steel bars, Siemens, £4 10s.; Bessemer, £4 8s. 9d. Iron ore, Rubio, Newport, 14s. 6d. to 14s. 9d. Other quotations, Swansea:—Block tin, £131 10s. cash, and £133 5s. three months; copper, £62 10s. cash, £63 10s. three months; lead, £13 7s. 6d.; spelter, £20 12s. 6d.; silver, 22½d. per oz.

Tin-plate.

Satisfactory trade in all quarters. Most mills busy, but nothing of interest occurring, only vessels going back to Batoum in ballast. Last week Swansea shipped 60,923 boxes, received from works 76,670, and stocked 208,143. Latest prices:—Ordinary Bessemer and Siemens, 12s. 3d.; ternes, 22s. 9d.; C.A. roofing sheets, £8 5s.; big sheets, £8 7s. 6d.; finished black plates, £9 7s. 6d.; galvanised sheets, 24 g., £12 10s. Associated trades are doing well—spelter, nickel, copper; tube works quieter.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, December 9th.

THE steel industry is improving very slowly. The volume of business for the past week was below the average of three or four weeks past. The largest locomotive order for the week was placed by the Chicago and Alton Railroad for twenty locomotives the contract price of which is 350,000 dols. Some of them are exceptionally heavy. The largest prospective structural steel contract is the projected Equitable building in this city, which is to be forty-three stories high; it will be built in Lower Broadway; the estimated steel requirements are 50,000 to 60,000 tons. Bids are being figured on. An addition to a department store in Philadelphia will take 12,000 tons. Bids are being made this week on 8500 tons material for the Northern Pacific, and 3000 tons for a viaduct at Denver, Colorado. Large apartment houses are to be built in this city this winter and next spring, and contracts have been awarded for between 15,000 and 20,000 tons for this purpose. The American Bridge Company, which is a branch of the United States Steel Corporation, has secured contracts for the steel span bridge across the Mississippi River at St. Paul, and also for the material for the Stock Yards Terminal Company at Chicago. The projected reduction of tariff on steel products is engaging a great deal of attention. A reduction of 25 per cent. is anticipated, which would make the duty on steel rails a little under 6 00 dols.; plates, 4.50 dols.; shapes, 7.50 dols.; wire rods, 3.75 dols.; and wire, 95 cents per 100 lb. The proposed reductions will hurt the independents more than the United States Steel Corporation, and in time may dispose some of them to sell out to the latter power. It is claimed that a final understanding has been arrived at between railmakers and buyers.

The copper market is dull. Conditions are against producers, but they are endeavouring to combat the situation, which they have done in the past successfully. The production of copper in the United States, Mexico, and Canada this year, will run close to 1,100,000,000 lb., or 550,000 tons, or about the production of 1907, against 1,172,256,695 lb. in 1906. The output in the United States, Canada, and Mexico is close to 110,000,000 lb. a month. At the present rate of consumption the present excess of production is 400,000,000 lb. a year. Electrification projects contemplated by railroads are looked to to absorb the surplus and maintain profitable prices.

BUSINESS ANNOUNCEMENT.—Stewarts and Lloyds, Limited, advise us that on and after the 21st inst. their London offices will be removed to Winchester House, Old Broad-street, E.C.

CONTRACT.—The Harton Coal Company, of South Shields, has ordered from Mr. Jos. H. Harrison, of Middlesbrough, a water-cooling plant, to deal with 45,000 gals. of water per hour. This order is for the Whitburn Colliery at South Shields, and the plant has to do its work with a pressure equal to only 7ft. head.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The third general meeting of the session will be held in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne, this evening at 7.30 p.m. The gold medals for the twenty-fourth session will be presented. The council has had under its consideration various amendments to the report of the educational committee, issued in December, 1903. These amendments will be submitted for the approval of the members at the meeting. The discussion on Mr. J. B. Duckitt's paper on "The Electrical Equipment of Cranes," will be resumed. A paper on "A System of Control for a Shipyard," by Mr. W. J. Wilson, will be read and discussed.

THE SOCIETY OF ENGINEERS.—The annual dinner of the Society of Engineers was held on Wednesday evening, the President, Mr. J. W. Wilson, being in the chair. The party was not very large, but the evening was marked by two admirable speeches in reply to the toast of "The Imperial Forces," given by the President. Admiral Sir Edmund Fremantle, in a very striking speech, urged the importance of laying down more ships if this country wished to maintain the two-Power standard. Lieutenant-General Hutchinson responded for the Army, and invited engineers to join the engineering branch of the Territorial Army. The Society is next year to be amalgamated with the Civil and Mechanical Engineers' Society, which celebrates its jubilee in a few months.

THE SPANISH NAVAL CONTRACT.—The telegram we publi-hed yesterday from San Sebastian, says the *Sheffield Daily Telegraph* of 17th inst., stating that the Advisory Committee had arrived at a decision on the subject of the £8,000,000 contract for naval construction in Spain in favour of the English group of tenderers, aroused the liveliest satisfaction in Sheffield, for associated in that group are Vickers, Sons and Maxim and John Brown and Co. The third firm interested is Armstrong, Whitworth and Co. This much-talked-of business is at last reaching a definite stage. According to the official "Gazette" the new fleet is to consist of three heavy-armoured vessels of about 15,000 tons (£5,400,000); three armoured destroyers or three submarines (£252,000); twenty-fourtorpedo boats (£1,123,200). The remainder of the eight million sterling is for expenditure on the three naval ports. The works are to be spread over a period of eight years. It is a stipulation in the contract that the ships shall be built in Spain.

PORT IMPROVEMENTS AT RANGOON.—The first of three special service steamers, which William Simons and Co., Limited, Renfrew, are constructing to the order of the Rangoon Port Commissioners, was launched on December 10th, the vessel being named Swallow, by Miss Buchanan, daughter of Mr. George C. Buchanan, chairman and chief engineer to the Rangoon Port Commissioners. The Swallow and her sister ships are each of 1000 tons deadweight carrying capacity, and are specially designed for carrying stones and rubble across the Gulf of Martaban to Rangoon in connection with the formation of retaining walls, &c., at the latter port. The propelling machinery consists of one set of triple-expansion surface-condensing engines and large multitubular high-pressure boilers, designed for burning inferior coal and capable of supplying the engines with steam for a speed of 10 knots. The hold for carrying the stones is divided into compartments, and the discharge doors are controlled by steam appliances designed so that each compartment may be emptied independently of the others, or that all the compartments may be discharged at the same time.

ROYAL METEOROLOGICAL SOCIETY.—The monthly meeting of this Society was held on Wednesday evening, the 16th instant, at the Institution of Civil Engineers, Westminster, Dr. H. R. Mill, president, in the chair. Mr. Eric S. Bruce read a paper on "Some Forms of Scientific Kites," in which he brought to the notice of the Society some forms of kites other than the well-known box kite invented by Mr. Hargrave. This is heavier and more breakable than many other forms of kites, but it possesses the indisputable advantages of stability, ascending steeply and exerting great force. When there is wind enough to fly it, it would appear unsurpassed. Mr. Bruce also described the Brogden six-winged bird kite, the Salmon eighteen-winged kite, the Barclay honeycombed kite, the Cody bat-winged box kite, the Balston butterfly kite, and the Burgoyne aluminium kite. Mr. C. J. P. Cave read a paper on "The Registering Balloon Ascents in the British Isles, July 27th—August 1st, 1908." These ascents were made in connection with the extended series of ascents of kites and balloons arranged by the International Commission for Scientific Aëronautics. Some of the records show considerable differences of temperature between the up and the down traces, which seems to indicate that fairly rapid fluctuations of temperature may occur in the upper air. The average height reached was 10.2 miles, the greatest height being 14.3 miles. All the balloons except one reached the isothermal layer, and show that the diminution of temperature with height ceases after a certain point, or that there is a rise of temperature; the rise of temperature is quite marked, even in the case of balloons which have attained their highest point after sunset, and cannot therefore be the effect of solar radiation. Mr. C. J. P. Cave also read a paper on "Balloon Observations at Ditcham Park, near Petersfield, July 27th—August 2nd, 1908.

NOTES FROM GERMANY.

(From our own Correspondent.)

Rheinland-Westphalia.

DECREASING employment is noticeable in many trades, and quotations remain weak on the whole. Pig iron is quiet, although compared with previous weeks a slight improvement in demand can be reported. Stocks at the blast furnace works having been almost cleared now, there is less underquoting going on, and the prices at present ruling for forge and foundry pig are about M. 8 p.t. higher than at the worst period, when M. 55 for hematite and M. 53 for foundry pig No. 3 was quoted. Deliveries on the Siegerland iron ore market have shown improvement during the week, and orders come in more freely. The restriction in output, which was 40 per cent. in October, and a little less in the present quarter, will probably go down to 20 per cent. for the first quarter next year. Towards the end of the present month a meeting of the members of the Iron Ore Syndicate will take place in Siegen, when the question of the restriction in output will be finally settled. Scrap iron is less depressed than before. On the malleable iron market little life is stirring, and the rolling mills are but indifferently occupied. Girders have been reduced M. 5 p.t. for the first two quarters in 1909, and a further reduction of M. 5 p.t. has been promised for special cases, but consumers are as reserved as ever. The business in bars is exceedingly small; the few orders available are generally secured by the mixed works. Producers find it difficult to realise M. 100 p.t., the price generally quoted being M. 93 to M. 95 p.t., which is less than what is paid for semi-finished steel. The plate trade is in a similar condition, heavy plates being poorly inquired for, while sheets are downright neglected. Employment in the hoop trade remains fairly satisfactory, but there is very little fresh work being offered.

The Iron Market in Silesia.

Occupation is steady and satisfactory, only quotations are so low that they leave no profit, and there is no hope for improvement. A comparatively good export trade is being done, especially to the East. The business to Northern Europe has been considerably curtailed by the competition of the Western works. Regarding the different branches of industry there has been a satisfactory activity in the pig iron trade; since the beginning of the present year Silesian ironmasters have been trying to reduce the output in proportion to demand. Several blast furnaces of the district have been blown out, and stocks are by no means heavy; quotations, consequently, have been firmly maintained. In October of present year output of pig iron has been 77,906 t., compared with 79,207 t. in the same month last year. Since the beginning of present year 779,009 t., as against 783,991 t. in last year, have been produced. Prices are firm on the malleable iron market, and plenty of work has been secured for some months. Pipes are flat; rails have been in good demand, especially light-section rails. The machine and wagon shops have secured a fair amount of work. Girders and bars remain in limited request.

Production of Pig Iron.

According to official statements given by the Union of German Iron and Steel Masters, the output of pig iron in Germany, including Luxemburg, was for November last 930,738 t., as against 941,582 t. in October of present year, and compared with 1,112,225 t. in November, 1907. Production of the different sorts of pig iron was as follows:—Foundry pig, 199,320 t., against 189,942 t. in November last year; Bessemer, 20,856 t., against 36,747 t.; basic, 593,625 t., against 716,333 t; steel and spiegeleisen, 72,215 t., against 98,741 t.; forge pig, 44,862 t., against 70,462 t. From January to November of present year the output of pig iron was 10 796,985 t., against 11,939,385 t. in the same period last year.

Coal in Germany.

In the Ruhr coal district only a very moderate demand comes in for engine fuel, while house coal is in fair request. Demand and sale on the Silesian coal market are steady, and there was rather more inquiry coming in on foreign account.

Steady Trade in Austria-Hungary.

Merchant bars and sectional iron are reported to have been in slightly better request than previously, and there was a little more life stirring in most departments. In the Austro-Hungarian coal industry demand is about equal to consumption; coke was in rising request during the week.

The French Iron Trade.

Compared with the iron markets in other countries the condition of the French iron industry has been fairly good for some time past, still the slight revival that has set in recently was greeted with satisfaction, and ironmasters are even contemplating a rise in quotations for some articles. Consumers continue to show a marked disinclination for forward contracts.

No Improvement in Belgium.

The business in pig iron is confined to very small sales for immediate use. Especially forge pig remains exceedingly neglected, with the result that prices have become easier. For forge pig 59f. p.t. is quoted, basic stands on 63f. p.t., and foundry pig No. 3 realises 67 50f. p.t., free place of consumption. During the first ten months of this year the export in semi-finished steel was 74,884 t., as against 25,253 t. for the corresponding period last year; import, during the period before mentioned, only rose from 84,092 t. to 93,695 t. The export trade in girders is extremely limited, being little more than one-half of last year's export. Inland consumption is also languid. The rail trade is in a comparatively favourable state, although here, too, foreign competition not infrequently frustrates sales at the very last moment. South America is a good customer. In the course of last week an order for 16,000 t. rails for the Belgian State Railways was secured at 139f. p.t., while German and French competitors asked 9f. p.t. more.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made by the Admiralty:—

Engineer Commanders.—W. R. Lawton, to the Black Prince; D. J. Carruthers, to the Queen, on recommissioning; A. T. H. Stone, to the Blenheim, additional, for duty in connection with t.b.d.'s; W. A. P. Smith, to the Pembroke, additional, for the Vulcan; and A. Hart, to the Acheron, for supervision of instruction of second-class stokers *vice* Rayner, who is to remain fourteen days with his successor.

Engineer-Lieutenants.—F. F. May and S. G Wheeler, to the Queen, on recommissioning; J. D. Wilson, to the Attentive; W. L. Moore, to the Sapphire, additional, for the Leven; J. M. J. Murphy, to the Sapphire, additional, for the Falcon; W. Dalton, to the Hecla, additional, for the Kestrel; F. C. R. Paton, to the Excellent, additional, for the Revenge; L. Howell, to the Pembroke, additional, for the Apollo; A. J. Mackean, to the Blake, additional for the Sprightly.

THE accumulator cars to be used on the railway from Mayence to Münster, Germany, weigh, with passengers, 62 tons, and the energy consumption at a speed of 45 kiloms. (28 miles) per hour averages about 12 watt-hours per ton-kilometre. This includes the energy consumption of one start. The road has some grades of 0.5 per cent. and several sharp curves.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

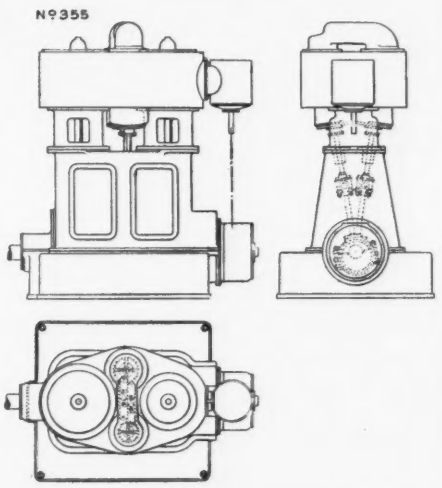
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end o the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM ENGINES.

355. January 6th, 1908.—AN IMPROVED DESIGN OF RECIPROCATING ENGINES, by Belliss and Morcom, Limited, and Albert Ernest Teague, both of Ledsam-street Works, Birmingham.

The objects of this invention are to obtain greater compactness, particularly with respect to the dimension as measured in the direction of the axis of the crank shaft and the minimising of the length of the steam passages to and from the cylinders, particularly in compound engines. In accordance with this invention the valves are interposed between the two cylinders, but instead of the centre lines of travel of the valves lying in the longitudinal plane through the axis of the shaft which contains the centre lines of the pistons, the centre lines of the valves are arranged to

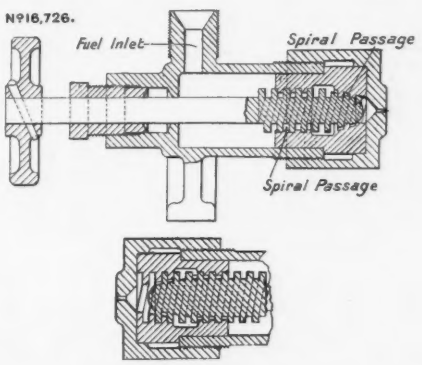


be oblique to such central plane on opposite sides of it, the centre lines of valve travel being so directed as to incline towards or intersect the axis of the crank shaft. Further, for the purpose of enabling the valves to be independently operated by separate excentrics, the centre lines of the travel of the valves are so inclined to the central plane as to incline towards or intersect the axis of the crank shaft at points sufficiently distant from one another as to enable the shaft to carry two side-by-side excentrics whose central traverse planes either contain the centre lines of the valve movement or are away therefrom in opposite directions to an extent insufficient to present any mechanical difficulty due to indirect application of the urging forces on the valves.—*November 25th*, 1908.

STEAM GENERATORS.

16,726. April 13th, 1908.—IMPROVEMENTS IN OR RELATING TO LIQUID SPRAYERS OR BURNERS, by John Edward Thornycroft, of Church Wharf, Chiswick.

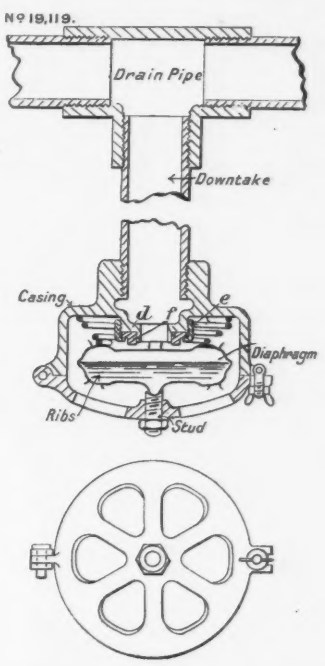
This invention relates to burners for liquid fuel. The object is to provide a simple form of sprayer in which the co-acting threaded portions adopted for advancing and retracing the orifice controlling plug are adapted to impart the necessary motion to the liquid, thoroughly to disintegrate the oil as it is sprayed. The construction is illustrated by the accompanying engraving, and Fig. 2 is a modification. In each case it will be seen that the



whole of the liquid passing through the sprayer is constrained to flow through the helical passage formed between the screw-threaded parts and issue with a whirling motion; that the cross sectional area of the outlet end of the passage can be varied to suit requirement; that by screwing the spindle forward any obstructing matter between the forward portions of the co-acting screw-threaded parts can be crushed, and by screwing the spindle backward, so as fully to open the passage, the obstructing matter can be forced out of the sprayer by the liquid.—*November 25th*, 1908.

19,119. September 11th, 1908.—IMPROVEMENTS IN STEAM TRAPS, by William Ernest Laycock, of Victoria Works, Millhouses, Sheffield.

This invention relates to steam traps, and deals particularly with the expansion chamber. In order that the casing of the expansible chamber may be at all times free from any accumulation of water, the body is dished shaped and has a number of comparatively large perforations in it. Referring to the engraving, it will be seen that there is a cylindrical casing secured to the end of the downtake pipe, and within which casing is disposed the expansible chamber or diaphragm of ordinary form and construction. The casing has formed within it an extension *d* having an external screw thread with which engages a union *e* having an internal projection whereby the ring *f*, formed of vulcanised fibre or other suitable material, is secured to the extension. The ring forms a seating with which the upper surface of the expansible chamber comes into contact when heated. Interposed between the top of the chamber and top of case a spring is interposed whereby the

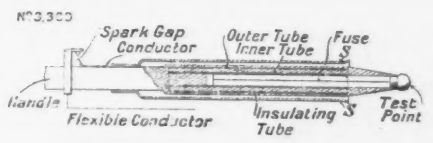


vertical displacement of the chamber is prevented. Ribs within the casing prevent lateral displacement. The cover is secured to the case in the closed position by means of a bolt and fly nut. The cover is perforated as shown, and is dished so as to facilitate the discharge of the condensed steam. The stud at the bottom passes through the centre of the cover and permits the ready adjustment of the chamber.—*November 25th*, 1908.

SWITCH GEAR.

3369. February 14th, 1908.—IMPROVEMENTS IN OR RELATING TO MEANS FOR INDICATING OR DETECTING THE EXISTENCE OF HIGH VOLTAGE TO WHICH A BODY MAY BE ELECTRICALLY RAISED, William Mundell Thornton, of Clermont-villas, Forest Hill, Northumberland, and Henry Clothier, of Walls-end-on-Tyne.

This invention relates to means, embodying a condenser and spark gap, for indicating or detecting the existence of high voltage to which a body may be electrically raised, and is more particularly intended for use in connection with alternating electric current. In the portable form of apparatus a tubular condenser may appropriately be adopted. Thus, as shown partly in section and partly in elevation in the engraving, an inner cylindrical tube is carried within a support or handle of suitable material so that

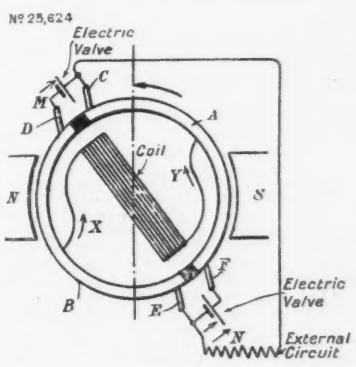


it is well insulated whilst a test button or point arranged at one extremity of the support or handle is connected through a fuse to the tube. An outer concentric tube in inductive relation to the inner tube is also carried by the support or handle and well insulated from the inner tube, as also, it may be, exteriorly, by an insulating tube, whilst a conductor extends from the said outer insulated tube to one terminal of the spark gap. This terminal is mounted upon the support or handle, and the co-acting terminal is carried by a ring or the like, also mounted on the support or handle and connected to earth, by a flexible conductor. For use in exposed positions an outer protective sheath may be provided to keep the surface of the outer insulation dry. There are four claims and nine illustrations.—*November 25th*, 1908.

DYNAMOS AND MOTORS.

25,624. November 19th, 1907.—IMPROVEMENTS IN COMMUTATING DEVICES FOR ELECTRIC MACHINES, Miles Walker, of The Cottage, Leicester-road, Hale, Cheshire.

The object of the present invention is to enable the commutating

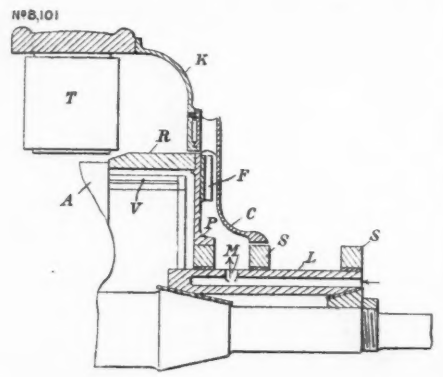


electromotive force to be adjusted to a sufficiently high value to effect a complete reversal of the direction of the current in the

section under commutation without involving the sparking due to over-commutation. For this purpose a compound brush is employed, as shown in the accompanying engraving This compound brush consists of two or more parts which are connected together by means of an electric valve or valves, so constructed as to permit current to flow only in one desired direction. The engraving, which is one of eight given in the specification, shows an arrangement by which the current generated in a single open coil rotating in a magnetic field between N and S poles can be commutated and supplied to an external circuit. When the coil is in the position shown, and revolving counter clockwise, the direction of the electromotive force generated is indicated by the arrows X Y, the terminals of the coil being connected to the two segments A B of the commutator, which are separated by insulating segments. The commutator brushes, as above stated, are compound and comprise two pairs of brushes C D and E F, the brushes C D being separated by an electric valve arranged so that currents can only pass in the direction indicated by the arrow M, and the brushes E F being separated by an electric valve arranged so that current can only pass in the direction indicated by the arrow N. There are eight illustrations and five claims.—*November 25th*, 1908.

8101. April 11th, 1908.—IMPROVEMENTS IN COOLING THE COMMUTATOR OF A DYNAMO-ELECTRIC MACHINE, Siemens Brothers, Limited, of 12, Queen Anne's-gate, Westminster, and Claud Martineau Toplis, of 44, Lichfield-road, Stafford.

In specification No. 7255 of 1906 is described a method of cooling the commutator of a dynamo-electric machine by causing air to pass through longitudinal passages in the commutator bars. Dust collects in these passages, and must be periodically removed in order that the air may not become obstructed. This invention is intended to overcome the troubles arising from this. When cleansing the passages the dust is swept into the armature with the original form of construction. Referring to the engraving, T is a field magnet, A the armature, L one of the commutator bars.

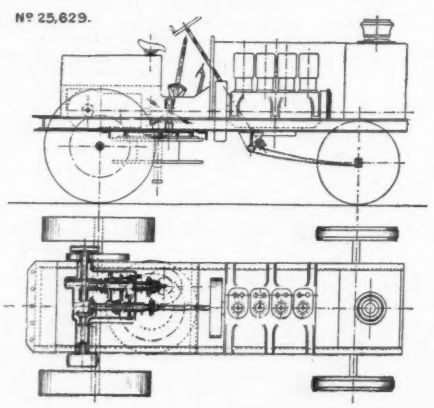


Rings S hold the bars to the shaft in known manner. The armature winding and connections V are protected by a ring R and to this is fixed an annular plate P, the enclosure being completed by a cap K extending from this plate to the part that carries the magnets T. The longitudinal passage through the commutator bars terminates at a short distance from the rear end of the bars, and the radial passage M completes the air way indicated by the arrows. To the plate P are fixed blades F and to the cap K is screwed a shield C which extends close to one of the rings S. There is thus constructed a fan constituted by the blades F revolving in the casing formed by the plate P on the one hand and the shield C on the other, and the air is drawn through the commutator bars by action of this fan. There are three illustrations and four claims.—*November 25th*, 1908.

MOTOR CARS AND ROAD TRAFFIC.

25,629 November 19th, 1908.—IMPROVEMENTS IN TRACTORS OR TRACTION ENGINES OF THE INTERNAL COMBUSTION TYPE, by Herbert John Marshall, of Britannia Works, Gainsborough.

The object of this invention is to provide in the form of a tractor engine for agricultural and general purposes. As will be gathered from the engraving, the engine is so arranged that the machine may be built with two, four, six, or more cylinders without altering the general design of the machine or the transmission gearing. At one end of the machine a gear-box is constructed which contains the necessary gear wheels for changing speed and reversing, and also giving motion to a shaft at right angles carrying a driving pulley, the latter being arranged in a convenient position inside the line of the travelling wheels, so that the driving belt is length-

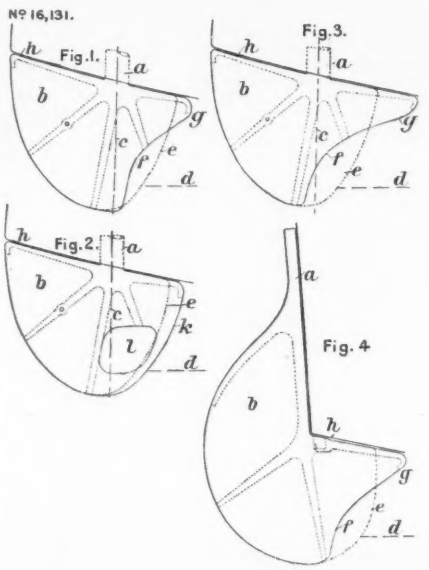


wise of the machine. Combined with the arrangement of engine and gearing, a horizontal winding drum is sometimes added, and this is mounted under the frame of the machine, and driven from the shaft of the change-speed gear by bevel wheels. The construction of the machine is such that the winding drum may be fitted without affecting the utility of the tractor for hauling or belt driving, or altering the general design. A tank is provided at the rear of the machine for containing the liquid fuel, and also the water for cooling the engine cylinders, the water after passing through the cylinder jackets being circulated through a cooling tank on the front of the machine, which is fitted with internal corrugated trays over which the water passes, and when the machine is ascending or descending an incline, the water falls from the trays in thin streams due to the corrugation, the same as when the machine is level.—*November 25th*, 1908.

SHIPS AND BOATS.

16,131. July 29th, 1908.—IMPROVEMENTS IN BALANCED OR PARTIALLY-BALANCED RUDDERS, by the Palmer's Shipbuilding and Iron Company, Limited, and James Lindsay Twaddel, both of Ellison-place, Jarrow.

In modern high-speed vessels having more than one screw propeller, and having a balanced or partially-balanced rudder or rudders whose axis intersects or nearly intersects that of one of the propellers, difficulty has been experienced in so balancing the rudder as to admit of it being readily brought back to midship position after having been put over to port or starboard, both in going ahead and in going astern. In going ahead this is found to be largely due to the propeller race impinging on the forward portion of the rudder, and setting up a force, acting against its return to said midship position. In order to maintain the balance and yet relieve this force, according to the present invention the rudder is made of a form in which the area of the forward part of the rudder is obtained by extending the upper portion thereof, or enlarging said forward part in an upward direction, while clearance

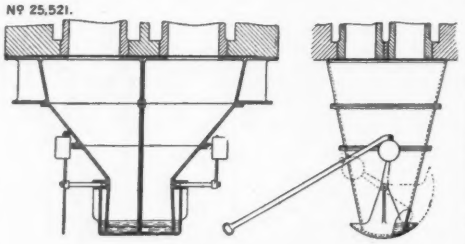


for the propeller race is obtained by reducing the area at that portion which lies in the way of line of the propeller. Four alternative forms of the improved rudder are shown in elevation in Figs. 1, 2, 3 and 4. Referring to Figs. 1, 3 and 4, the outline of the forward position of the rudder as usually made is shown by the broken line *e*, whilst the line *f* shows the improved outline of the forward portion of the rudder to give clearance for the propeller race, the part removed at this portion being compensated by adding the forward extended upper portion *g*. In the form shown in Fig. 2 the forward outline is shown by the line *k*, which is carried further forward than the usual outline *e*, that is to say, enlarged in an upward direction, and a portion is removed from the rudder at *l* to afford clearance for the propeller race.—*November 25th*, 1908.

MISCELLANEOUS.

25,521. November 18th, 1907.—OUTLET DOORS FOR VERTICAL RETORT-DISCHARGING APPARATUS, by Samuel Glover, of Olivemount, St. Anns, St. Helens, and John West, of The Firs, Park-road, Southport.

This invention relates to the outlet doors of hoppers or receptacles which receive the coke discharged from vertical retorts used in the distillation of gas, coal and shale, and has for its object to form a hermetically-sealed water or liquid joint between the outlet doors and the hoppers. In order to accomplish this object the door is made in a segmental form, and is suspended from trunnion pins, from the centre of which the segmental door partially revolves when being opened or closed. This door has sides which, together with the segmental-shaped portion, form a shallow dish



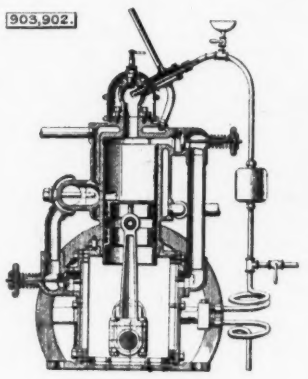
capable of holding water. The lower ends of the hopper, which is a receptacle for the coke from the retort or retorts, project into the dish-shaped space of the door when the latter is closed, and the dish-shaped door is filled with water above the level of the edge of the hopper mouth, consequently a water seal is formed, and the door is hermetically sealed against the exit of the gas or the ingress of atmospheric air. The doors are operated by levers arranged so that they can be swung open by partially revolving them round the trunnion centres, and the door is counterbalanced so that the operation of opening and closing is easily effected by the attendant. When the door is opened the water contained in it for forming the seal joint is emptied along with the coke discharged, and when the door is returned to its closed position a further quantity of water is supplied to form the water seal.—*November 25th*, 1908.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

903,902. COMBUSTION ENGINE, *O. G. Simmons, Washington, D.C.* —*Filed December 21st*, 1907.

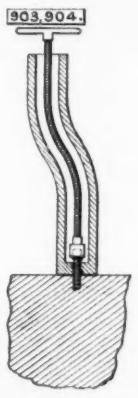
There are seven long claims, mainly a list of parts. Air is heated by impinging through holes on the exhaust. The heated air is taken into an enclosed crank casing. The fuel—hydrocarbon—is supplied by a small pump to the ignition chamber at the end



of the cylinder. Suitable water jackets are provided. Speed is regulated by a shafting cam which works the fuel-feeding pump.

903,904. WRENCH, *A. C. Smith, Dobbs Ferry, N.Y.* — *Filed January 8th*, 1908, *renewed October 1st*, 1908.

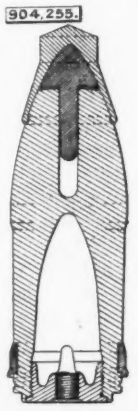
This is for a spanner with a wire rope shank which can be used



on a nut at the ends of crooked pipes, as, for example, in some forms of boilers and superheaters. There are six claims.

904,255. PROJECTILES, *E. Gathmann, Bethlehem, Pa.*—*Filed December 7th*, 1907.

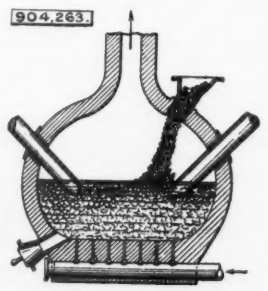
The patent is for an armour-piercing projectile provided with a point, a bursting charge chamber in its rear, and an axial shrink-



age bore in its head portion, the said bore being closed at its rear end by a barrier, and at its forward end by the projectile point, the said point not being integral with the major mass of the projectile, or with the separating barrier. There are ten claims.

904,263. PROCESS OF OBTAINING METALS FROM THEIR ORES, *K. Kaiser, Berlin, Germany.*—*Filed June 22nd*, 1906.

This patent is for a method of obtaining metals which consists in heating raw materials containing such metals, in an electric



furnace, until such materials melt, then forcing air into contact with the molten mass, and then forcing a gaseous reducing agent into contact with the molten mass until the metals therein are reduced. There are four claims.

THE discovery is announced of an oil bed in the south-east district of Madagascar, the possibilities of which are at present being investigated. Samples of oil have been sent to Paris for analysis.

ELECTRICITY IN GERMANY AND BRITAIN.

(*From a Correspondent.*)

THE address delivered by Mr. W. M. Mordey, the President for the year of the Institution of Electrical Engineers, upon "Some Comparisons of the Electrical Industry in this Country and Abroad," was so interesting and important in its subject matter that it has given rise to a large amount of discussion and some controversy in professional circles. Mr. Mordey's paper was chiefly composed of statistical tables. No one has disputed the accuracy of his figures, or could well do so; nor has any disposition been shown to doubt the scrupulous fairness of his selection of groups of towns and districts from which to draw averages for the purposes of the comparisons he makes.

There are, however, aspects of the question which have not received the attention they deserve. The comparison that naturally excites most interest is that between Germany, the country where Mr. Haldane thinks technical efficiency has reached much higher grades than elsewhere, and ourselves. There are five divisions of the subject in which comparison may yield useful lessons:—(1) Manufacture of electrical machinery and fittings; (2) general utilisation of electricity; (3) costs of electricity generation; (4) profits; and (5) technical training.

Mr. Mordey did not touch upon (1) because he desired to offer no opinions unsupported by incontrovertible figures, and full manufacturing statistics are not available. The general nature of the facts, however, are simple enough. In the manufacture of fittings and instruments this country has been quite as productive as others abroad, and no sensible difference either as to quality or price, or profitableness to the makers can be predicated. We have manufactured a much less quantity of machinery, and no firms or companies for such manufacture comparable in size or in activity to those abroad exist in Britain. On the other hand, there has not arisen at home any need of "concentrations," or what have been euphemistically termed "amalgamations," whereby in foreign territory at least two enormous and splendid businesses have been absorbed in that kind of fraternal spirit which probably leaves the absorber much happier than the absorbed.

As regards (2), so far as lighting is concerned, the fields open for electricity in Britain and on the Continent cannot be rationally compared, because electric light has to fight its way into being in competition with gas, and gas in most continental countries is, and must always remain, very much more expensive than with us. Lighting has, however, already ceased to be the dominating factor in electrical industry, and is doomed to become relatively less important still in the near future. But this advantageous lead given to the continental installations makes all the more remarkable the facts proved by Mr. Mordey's tables. These are that in large towns, excluding London and Berlin, England uses 25 units per inhabitant as against 13 in Germany; in medium English towns 24 as against 23½ in Germany are used; while in small towns the ratio is 22 to 20. In London and Berlin the total consumption per inhabitant is about the same, namely, 37 units; but of this London uses three times as much for light as for power, while Berlin uses only 3 for light to every 4 for power. Thus, if the small manufacturing industries of London were revived by any large effective electric power distribution scheme, she would probably use between two and three times as much as Berlin per inhabitant.

In respect of costs of generation, except in very small towns, the fuel costs only a few per cent. more in Germany, while wages, management, and establishment charges per unit generated cost, on the best estimate that can be made—here Mr. Mordey could not give full figures—not much less than double in Germany, indicating a very much higher labour and management efficiency with us. This is no new point to those who are familiar with the differences between our own works and those abroad. The figures we have mentioned do not refer to tramway work, which requires separate consideration.

As regards technical training, so far as concerns the attainment of physical arrangements and results and the reduction of costs by skilful systematisation, all the evidence is in favour of British efficiency. The scientific training in the German technical colleges is too laborious and brain-fatiguing, and it sends its pupils into the world already deprived of much of the mental energy needed for industrial success. On the other hand, our English technical colleges are only now beginning to be, or have only recently been, equipped in the manner needed to afford them opportunity of showing the best they are capable of, and it is to be reasonably expected that before many years have passed their standard of accomplishment will be considerably higher than it is now.

There remains the question of profits from electrical supply. Mr. Mordey's tables show that in large towns, while each German citizen uses only half as much electricity as we do, he pays twice as much per unit; that is, each German pays almost exactly the same as (slightly more than) each Englishman, but for only half the quantity, although the German uses a smaller proportion for power and a larger proportion for light—except in Berlin. The contrast is not so strong in the smaller towns, but it is still markedly in the same direction.

The consequence of this is that gross profits in Germany are at least 50 per cent. higher than they are here. In England they range from 5 to 11 per cent.; in Germany from 8 to 15½, and, in one case quoted, to 19.3. These are percentages of total capital employed, and interest and sinking fund are to be paid out of them. Now interest and sinking fund together absorb some 6 per cent. Mr. Mordey says nothing about depreciation, but the published accounts from which he draws his figures make it clear that the above figures allow only actually incurred costs for "maintenance and repairs," and that depreciation of plant has to be provided for out of the gross profits quoted. On some of these accounts amounts for either "depreciation" or "renewals fund" appear, but included in gross profits. In most of them depreciation is ignored, for the very evident reason that there is no money left out of the "gross profit" to provide therefor. Of course, the sinking fund goes a small way only in this direction. Mr. Mordey's "small" English towns yield no more than an average of 5.7, and the others an average of 7¾ per cent. gross profit. It thus becomes clear that, if proper account be taken of inevitable depreciation, Mr. Mordey has proved that English electrical undertakings are being worked at a loss, and that most German undertakings are yielding only a small profit.

Thus in electrical engineering British enterprise and British technical engineering in respect of labour, efficient machinery, and economic organisation are fully vindicated, but the outcome indicates a money loss so far as direct results are concerned. The most useful question to ask and to try to answer is, Why is this so?

Some important relevant facts do not appear in Mr. Mordey's paper, which is discreetly reticent on the whole question of profits. The first is that some years ago there was in Germany a great overspending of capital on electrical undertakings much beyond the market demand for the products. The result was a great deal of magnificent plant which is, and will be for long, a national asset, but whose unproductiveness to its owners led to much distress and to much writing off of capital. This was in manufacturing concerns, whereas Mr. Mordey's 12 to 15½ per cent. German profits are mostly upon municipal supply undertakings. But the practical financial reorganisation of the whole trade in Germany can hardly have failed to affect the municipalities. It certainly stimulated Germans to extraordinary efforts in competition with others outside their own country. It has been the reacting stimulus upon us that has very greatly reduced our costs of production during the last four years; and this is the second relevant fact not mentioned in the paper under review. If similar statistics had been compiled in like condensed form half a dozen years ago, they would have presented a very different aspect. It is rather the rapid progress we have made in economy than the actual present results that we ought to be very proud of.

The third important fact is that, along with our reduction of costs, there has been an almost equally rapid reduction of receipts per unit generated. Electricity is being sold at a much lower average price now than three or four years ago; and many engineers are convinced that it is being sold too cheaply, and that the Germans have been right in keeping up the price, even at the cost of restricting the output.

It is, in fact, for lack of training in that particular part of technical knowledge which deals with costs and profits that our electrical engineers have brought a portion of their trade to a dangerous proximity to positive loss, and have made it difficult to find capital for new large undertakings. The theory of the economy of the high load factor has been run to death, and has led to extravagant courses, which it is, and will remain, difficult to retrace. It has led to the selling of electricity for power under cost price. Because a machine which has not work to do during all the twenty-four hours of the day is not earning income during those hours in which it lies idle, therefore work must be found for those idle hours by selling the product at a price which does not cover any fair share of the capital charges of the machine! This extraordinary suicidal proposition, which is actually the basis of the rates at which electric power is being charged, proceeds on the assumption that power is a waste product, while light is the paying product, just as tar is a waste product in gas manufacture. But the whole historical progress of electrical engineering shows that power, instead of being a mere by-product in the production of light, will in the near future be the main staple of the industry, and that lighting will be a mere incident. Mr. Mordey's tables show that, even putting aside altogether tramways and railways, the supplies for power and light are already equal both in England and in Germany. Having started the supply of power on a false basis of unremuneratively low prices, the temporary advantage of stimulating into existence a large demand for power has been obtained; but it will be found hereafter extremely difficult to rectify the scale of charges so as to raise them to the real remunerative standard. The increasing large supplies of electricity for power purposes at non-profitable rates is the reason for the present absence of profit in most British electrical undertakings—apart from tramways—and the wild schemes for great "bulk" supplies at still lower rates which just now fill the air are only making the task of the necessary correction by way of raising the power prices more difficult by convincing the lay public that these low rates are amply enough profitable. Mr. E. Garcke's complaints in his long letter to the *Times* are so far justified; and Mr. Mordey's prediction of a gradual approach to a flat rate for all purposes, and his often expressed dislike of "maximum demand" and other differential rates of charging clearly support this view of the economic situation.

The present writer does not believe that it is economically sound to charge as much per unit for power as for light, because generation for the latter purpose is intrinsically more expensive than it is for the former, and because with the introduction of metallic filament lamps the cost of current has become relatively a much smaller part of the total cost of electric lighting. But it is of great industrial importance to call attention to the fact that lighting companies in their eagerness to fill up the valleys of their load curves have established a custom of charging too little for power, which custom bids fair to exercise an evil influence upon the future progress of electrical engineering. It is with this object that the present article has been written.

THE TRUE PRINCIPLES OF MECHANICS.

By SYDNEY A. REEVE.

No. II.*

FROM what has preceded it follows that any free mass-pair, containing energy in permanence of form, must embody an energetic condition consisting of a mean or central fund of special separation and tangential motion, on either side of which there vibrates another fund which undergoes periodic transformation between special and kinetic forms. The central fund can be greater or less, according to the distance of separation between the two when in the mean energetic condition. The vibratory fund can also be greater or less, quite independently of the central fund, according to the excentricity of orbit.

Of these two funds it is the latter only which is covered by the equations for energy which were given earlier in this paper.

Indeed, in order to understand what in reality is this thing, which is spoken of so familiarly as so simple in nature, "mechanical energy," it must be recognised that in the mean energetic condition—which, and not either extreme condition, is the true base—there exist in combination four distinct energy quantities. These four now possess no accepted names. They will have to be discussed in somewhat arbitrary language. They are:—

1. The space energy embodied in the mean energetic distance.

2. The motion energy embodied in the tangential or circular component of the motion at the mean energetic point.

3. The variation in distance of separation involved in the excentricity of orbit; the $S_0 - S$ of the equation for potential energy, or more accurately, the $\frac{1}{S_0} - \frac{1}{S}$ thereof.

4. The variation in velocity involved in the excentricity of orbit: the $V^2 - V_0^2$ of the equation for kinetic energy.

Of these four energy quantities, the first two are characterised by their unchangeableness. As to the mean energetic distance, while it can be changed as outside influences change the orbit, yet for any one orbit, which may exist indefinitely, it remains constant. As to the tangential motion of the mean energetic condition, the same is true of it; for any one orbit it never changes its direction or velocity.

The second two are characterised by their periodic change of sign, or their vibration, from a condition of maximum separation and minimum motion to the opposite. Their amount is visible, in the mean energetic condition, in the radial component of motion there, or in the excentricity of orbit. If β be the angle between the direction of motion, in the mean energetic condition, and the radius vector joining the two bodies, and e be the excentricity of orbit, then $\cot \beta = e$ is the prime factor in measuring the proportion of vibratory to constant energy fund.

It will be useful to contrast the first pair of energy quantities with the second, in further argument, under the terms constant and vibratory energies respectively. While the terms are not finally satisfactory, they will do for the present.

It will also prove to be of prime importance, especially when these mechanical concepts are applied to an understanding of heat, to distinguish between *radial* and *tangential* activities. For this distinction the first, third, and fourth must be classed together as radial, leaving the second alone as purely tangential. For space energy is necessarily always radial in character. The usefulness of this distinction will be brought out in a future paper.

From the laws of Newton and Kepler, and from the mathematical properties of the conic sections, the natural

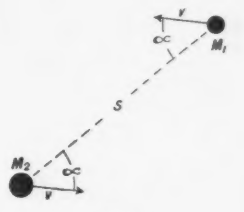


Fig. 1

orbit of any pair of bodies whatever, such as shown in Fig. 1, may be reduced by means of the relations shown in Fig. 3, to exact terms, as displayed in Fig. 4—although the result may prove to be an hyperbola instead of an ellipse. In Fig. 3, S is the half latus rectum, or the mean energetic distance, of the orbit, V is the instantaneous velocity at this point in the orbit, β is the angle between velocity and latus rectum, and γ is the angle between the original known vector and the latus rectum. The values of S, V, β, and γ can be computed from M_1, M_2, s, v, and α, by means of four equations drawn from the properties of the conic sections, from Kepler's law of velocity, from the principle of the conservation of energy, and from the balance between centrifugal and centripetal forces respectively.

These equations are sufficiently complex, so that a single final expression for the energy fund of any pair, in terms of any original condition, such as Fig. 1, is too cumbrous for practical use. The main point to be argued is that there always exists such a rigid and exact relationship between any original condition of relative separation and motion and its resultant conic-section orbit, from the latus rectum, of which the energy fund of the pair can be definitely understood.

The major axis of the orbit, or X X, lies normal to the latus rectum. The condition of the pair may hereafter be referred solely to it, together with S, V, and β, the

* No. I. appeared December 18th.

values of s, v, a, and γ being disregarded. The radial motion is then given by V cos β, and the tangential by V sin β.

According to the varying original conditions of relationship between the pair, the resultant orbit may have any form or dimensions, within the mathematical limits of the conic sections. Its mean energetic distance, indicative of the general scale of the orbit, may be very great or very small. It may possess any magnitude, from molecular to celestial. The excentricity of orbit may also be anything, from virtually zero to an inconceivably great

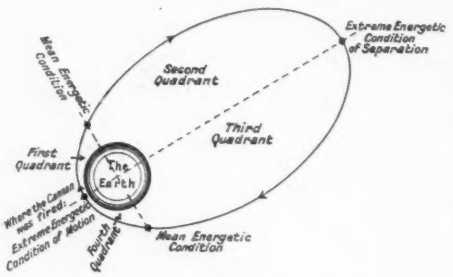


Fig. 2

quantity. According to the value of this excentricity, the geometric classification of the form of orbit will be as follows:—

Value of e = cot β.	Value of β. Deg.	Character of Orbit.
$e = 0$	90	Circle
$1 > e > 0$	45 to 90	Ellipse
$e = 1$	45	Parabola
$e > 1$	0 to 45	Hyperbola
$e = \infty$	0	Straight line

Of these forms therefore the circle, embodying zero vibratory energy, on the one hand, and the straight line, embodying zero constant energy, on the other, constitute the two extremes, or mathematical limits.

In nature, it will appear, the chances are infinitely against the occurrence of either of these extreme forms, the circle or the straight line. Indeed, this language is not strong enough. It will appear that it is naturally impossible—as impossible as perpetual motion—for either of these forms to be quite reached; although, under unusual circumstances, they may be closely approached.

Midway between these two extremes lies the parabola. This form of orbit constitutes the dividing line between elliptic and hyperbolic motions respectively. Since only one value for e, out of an infinite possible number of

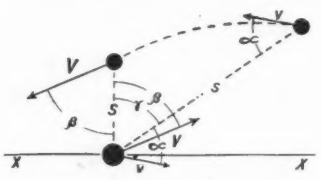


Fig. 3

values, would make the orbit parabolic, that form of orbit, too, is virtually non-existent. But whereas the circular or rectilinear forms may never be reached, even for an instant, the parabolic form may frequently exist instantaneously, in the crossing from elliptic to hyperbolic motion or the reverse.

Whatever the form of orbit and degree of excentricity, the quantity of energy transformed or manifested between the two mass portions, in passing from either extremity of the latus rectum to either vertex of the orbit—to periastron or apastron in astronomical terms, or to points of least or greatest separation in popular language—is equal to that transformed in passage between the latus rectum and the other vertex. In other words, the latus rectum position is the mean energetic condition of the pair.

This important fact may be most easily understood in the case of an elliptical orbit, in which both vertexes, (both periastron and apastron), are visibly present. At periastron the two bodies are in closest approach, the velocity is at its maximum, the radius of curvature of path is at its minimum, and the forces in equilibrium, both centrifugal and centripetal or gravitational, are at a maximum. The energy is chiefly kinetic, as we usually view it. At apastron the bodies are in greatest separation, the velocity is at its minimum, and the forces at work are at a minimum. The energy is then chiefly potential, as we commonly use the term.

As the bodies pass from periastron to apastron kinetic energy is converted into potential. As they complete the next semi-revolution the potential energy is reconverted back into kinetic. At some point on the outward trip, and at another on the return, the energy-conversion will have been just half performed. The fund of energy belonging exclusively to the pair will then be evenly divided between kinetic and potential forms. This point is the extremity of the latus rectum of the orbit, and constitutes the mean energetic condition. This is true, however great may be the excentricity.

It is worthy of note how important a part in energetics is played by angular displacement of revolution of the two bodies about each other. Ninety degrees of revolution convert the mean energetic condition into an extreme kinetic condition. A second quadrant of revolution converts it back again. A third quadrant converts the mean condition into an extreme potential condition; and the fourth quadrant brings the condition back to mean again.

Even where the four quadrants are not all present, as in hyperbolic orbits, this same law holds true, although disguised. If the line of the latus rectum be regarded as representing a plane normal to the plane of the orbit, the mass-portion which is regarded as the moving one would be veritably reflected from this plane; and so would its energy. Only, in the case in question, the reflection would be accomplished only after the projectile had passed through the plane of reflection, instead of merely impinging upon its surface. The significance of this fundamental fact in mechanical energetics will be found to be greatest in the consideration of elasticity and impact in their mechanical aspects—the topic of a later paper.

It has already been noted that the energy of any mass-pair, when in the latus rectum position or the mean energetic condition, consisted of two components, viz., that consisting of unchanging tangential motion and constancy of space, on the one hand, and that consisting of periodically reversing radial motion and variation of space, on the other. The mathematical expressions for the latter portions, potential and kinetic respectively, were given early in this article. It is now to be noted that for the constant or tangential fund no exact expression is possible. This form of relationship can absorb energy from without until its radius becomes exceedingly great; yet it will still be capable of absorbing more. For no degree of separation can reduce the resisting force to zero. On the other hand, the circular form of relationship can give out energy until S_0 becomes inconceivably small, and $\frac{1}{S_0}$ becomes inconceivably great; and yet, because there is no limit to the increase of $\frac{1}{S_0}$ as S_0 approaches zero, the system will still be capable of rejecting more energy. In short, the ability of any mass-pair, if conceived as concentrated at two geometric points, either to absorb or give out energy, is unending. It is

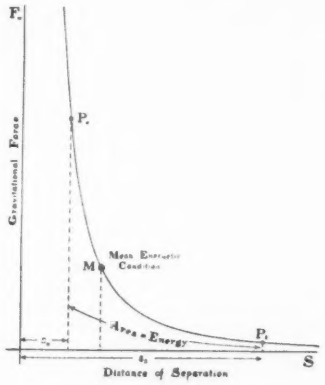


Fig. 4

quite inconceivable that there should be any exact expression for the total fund of energy of any pair or system, or any "absolute zero" from which to measure such.

In short, it should be the first lesson to the student of general principles of Nature that no natural quantity—such as distance, velocity, force, pressure, density, energy, &c.—may ever be conceived as totally absent, or zero. Throughout the universe prevail mean values for all of these variables. Here they vary below the mean, there above; but nowhere can they ever sink to zero or rise to infinity.

It is only measurements or perceptions of changes in these variables which are possible to man. The gross measurement of the variables themselves, as absolute quantities, is impossible, because the lapse of any variable to zero is inconceivable—a fact which will receive amplification in the next paper. What energetic sensations man possesses are merely of departures above or below the local mean value. What concepts he may have of energy are all of departures above and below the local mean of the variable in question. Either unusually great or unusually small velocity, or distance, or force, or temperature, &c., equally constitute a sense of disparity which man calls energy.

The understanding of these things must await further discussion of detail. Enough has been said to show that the ordinary concept of energy as a simple attribute of undivided mass, as defined by "force, times, distance," or as any function of force, distance, or motion, which passes readily to an absolute zero, is grossly inconsistent with Nature. That it has proven inadequate for a satisfactory mechanical concept of heat is not surprising.

THE WORK OF SUPERHEATER AND COMPOUND LOCOMOTIVES.

By Charles R. King.

The annexed charts showing the power capacity of superheater boilered and compounded engines, the one compared with the other, are compiled from railway profiles, train speed records, and loads hauled.

The speeds, in all save Fig. 2, are scaled above the profile of the line, and the loads hauled are scaled above the speeds. The result of gradient, speed, and load is thus combined in one single diagram.

Usually, an automatic speed record of a train moving at 70 miles per hour is of itself suggestive of great power output. The diagram has, however, to be referred to the line profile, which perhaps shows a falling gradient of 1 in 90, and upon which portion the engine regulator was completely shut. The diagram at this point, then, has no interest as an example of locomotive power; but, by scaling the speeds from the line profile, the resulting line shows immediately, at a glance, the relative values of work done on ascending and descending gradients, no further references being required.

In these examples those superheater locomotive records have been chosen which have been stated to be "brilliant results showing the extraordinary capabilities of the method; such results never having been obtained with saturated steam in engines of the same weight and number of axles." They are expressly stated to be "ideal maxima" resulting from special trials under exceptionally favourable conditions of running.

The compound locomotive records are mostly those of an old engine undergoing its first period of trial in Italy They are not by any means intended to represent the maximum for compound locomotives, but are simply used in these comparisons because they chance to be records of trips comparable, for gradient and length of run, to those of the superheater locomotives also shown.

The chart Fig. 2 comprises: (1) Speed record and line profile of Prussian State Railway—already frequently published as a remarkable result. (2) Speed record and line profile of Italian State Railway. No. 1 is a superheater engine, heavier in weight, but pulling a less load than the compound No. 2. In this case the superheater locomotive surmounted an elevation 12ft. greater than the compound. Only the most difficult section of the road has been here selected for illustration of the running powers by either system of working. The weights of engines and trains are as follows:—

	Superheater.	Compound.
Weight, engine empty	61 tons	57.5 tons
Car load	394 ,,	397 ,,

The chart Fig. 1 comprises: (1) Speed record of the same Prussian superheater locomotive—already described as a remarkable result—upon another section of the same line, between Grunewald, near Berlin, and Sangerhausen. (2) Speed record of a compound engine, but upon a more difficult section of line—between Milan and Venice—by reason of an intermediate rise 42ft. higher than that of the German line. The weights of the engines and trains are as follows:—

	Superheater.	Compound.
Weight of engine empty	61 tons	60.5 tons
Car load	353 ,,	413 ,,
Coal consumption per 1000 ton-kiloms. run	27 kilos.	24.4 kilos.

The fuel consumptions are the average, for the superheater, of the whole special trial run of 197.6 kiloms., and return to starting point; and for the compound, of an ordinary express train in regular service on the trip Milan to Venice, equals 265 kiloms. In both of these cases the weight of engine and tender is included in the ton-kiloms. run. In later examples the engine will be excluded from the train weight.

The relatively small coal economy of the compound over the superheater locomotive must, in this case, be attributed to the important difference in the conditions of a prepared trial run and the much less economical *régime* of every-day train traffic. The average load of trains, engine, and tenders comprised in the German superheater and Italian compound runs referred to were:—

Superheater.	Compound.
471 tons	511 tons

Chart Fig. 4 comprises:—(1) Speed record of Belgian express locomotive fitted, as in the preceding cases, with Schmidt superheater; profile of the Belgian line Brussels to Quévy; (2) speed record of an Italian compound engine on the line between Sieci, near Florence, and Arezzo, on the road to Rome. The train loads in both cases were 355 tons. The weights of the engines empty are as follows:—

Superheater.	Compound.
64.25 tons	57.5 tons

The proportions of train loads hauled per ton of locomotive were 5.7 by the superheater and 6.1 by the compound.

Chart Fig. 1 contains no data that have, at present, been claimed as "ideal maxima" in superheater locomotive results, this record being of very recent origin. The superheater diagram was made by an Italian locomotive fitted, as before, with Schmidt superheater, in a trial run upon the Prussian line from Grunewald, near Berlin, to Nedlitz. The portion of the run actually shown is between Wannsee and Weisenburg; the rest of the run being on falling gradient worked with closed regulator.

The compound diagram was made by a (now) old compound locomotive on the line from Florence to Laterina. This is our first comparison in which the superheater locomotive is lighter in weight than the compound; but due allowance is made for this in scaling the loads hauled in per ton of locomotive in empty load condition. The new Italian locomotives with superheaters have been made light in weight by replacing four-wheeled trucks with a single pair of leading wheels. The newest compounds have also been benefited by a similar reduction of weight, and in the latter case the reduced weight amounts to 3 tons—a constructional detail affecting neither the superheater system nor compound system of the locomotives to which it has been applied. Allowance for this reduced weight in the new balanced compound locomotives has been applied in the case of the old compound whose results are recorded in the diagram Fig. 1. This same locomotive was exhibited at the Paris Exhibition, 1900.

An important factor of train resistance not taken into account by these charts is the large proportion of short-radius curves on the Italian lines. This is of very considerable importance, as may be seen by reference to the plan of the curves on the Italian lines, as compared with the relatively straight and easy alignment of both the German and the Belgian railways, whose profiles are given in the charts. Calculation will show that the power required to overcome the resistance due to the sharp, numerous curves on the Italian lines between Florence and Arezzo is much greater than upon the

THE WORK OF SUPERHEATER AND COMPOUND LOCOMOTIVES

(For description see page 662)

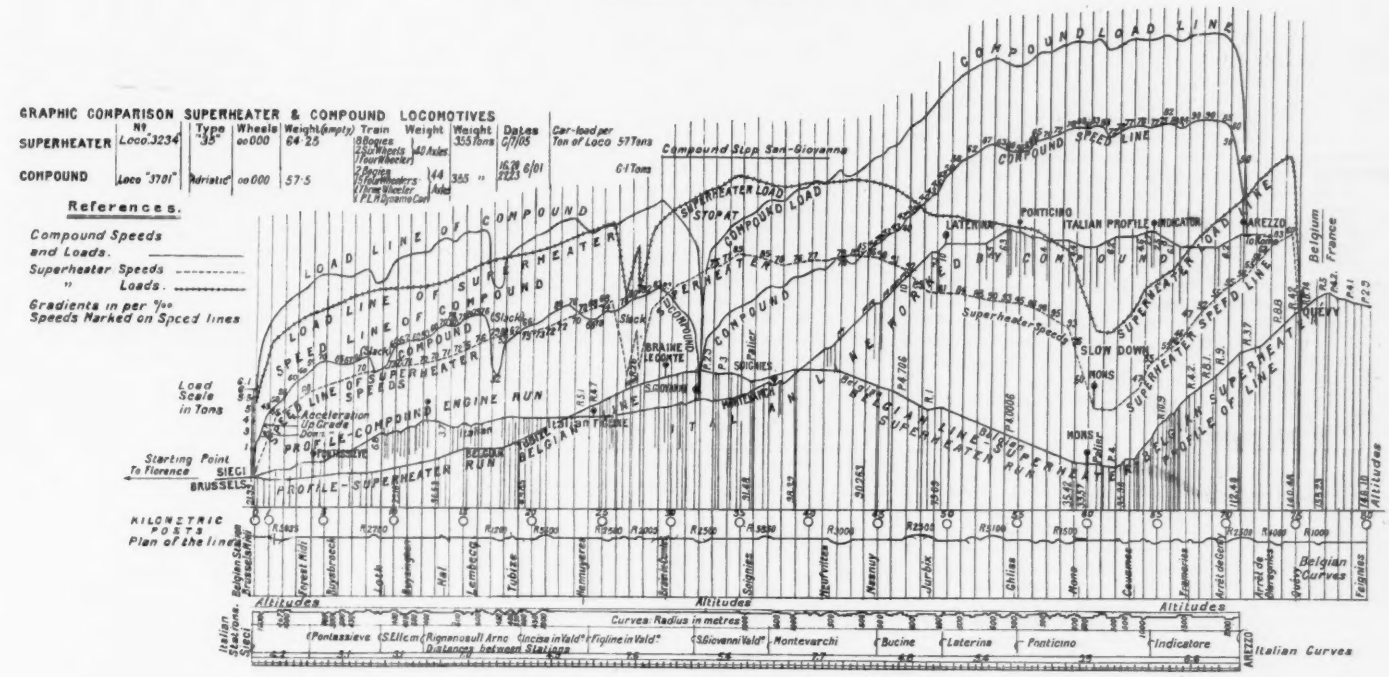
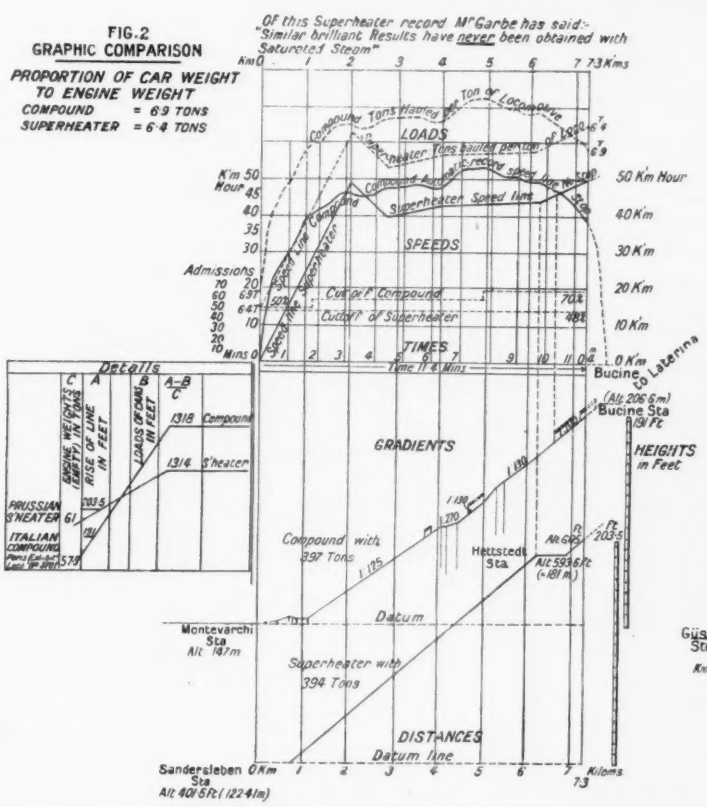

GRAPHIC COMPARISON SUPERHEATER & COMPOUND LOCOMOTIVES
SUPERHEATER Loco 3234 Type "35" Wheels oo000 Weight (empty) 64·25 Train 8 Bogies 2 Six Wheels 4 Four Wheels 40 Axles Weight 355 Tons Dates C/7/05 Car-load per Ton of Loco 5·7 Tons
COMPOUND Loco "3701" Type Adriatic Wheels oo000 Weight (empty) 57·5 Train 2 Bogies 4 Four Wheelers 1 Three Wheeler 1 PLM Dynamo Car 44 Axles 355 Tons Dates 16.28 2.23 6/01 Car-load per Ton of Loco 6·4 Tons
References.
Compound Speeds and Loads.
Superheater Speeds and Loads.
Gradients in per ‰
Speeds Marked on Speed lines
COMPOUND LOAD LINE
COMPOUND SPEED LINE
SUPERHEATER LOAD LINE
SUPERHEATER SPEED LINE
LOAD LINE OF COMPOUND
LOAD LINE OF SUPERHEATER
SPEED LINE OF COMPOUND
SPEED LINE OF SUPERHEATER
PROFILE-COMPOUND ENGINE RUN
PROFILE-SUPERHEATER ENGINE RUN
Compound Stop San-Giovanna
ITALIAN PROFILE INDICATOR
Load Scale in Tons
Starting Point To Florence
SIEGI
BRUSSELS
KILOMETRIC POSTS Plan of the line
Altitudes
Curves Radius in metres
Italian Curves
Belgian Curves
Belgium
France

FIG. 2
GRAPHIC COMPARISON
PROPORTION OF CAR WEIGHT TO ENGINE WEIGHT
COMPOUND = 6·9 TONS
SUPERHEATER = 6·4 TONS



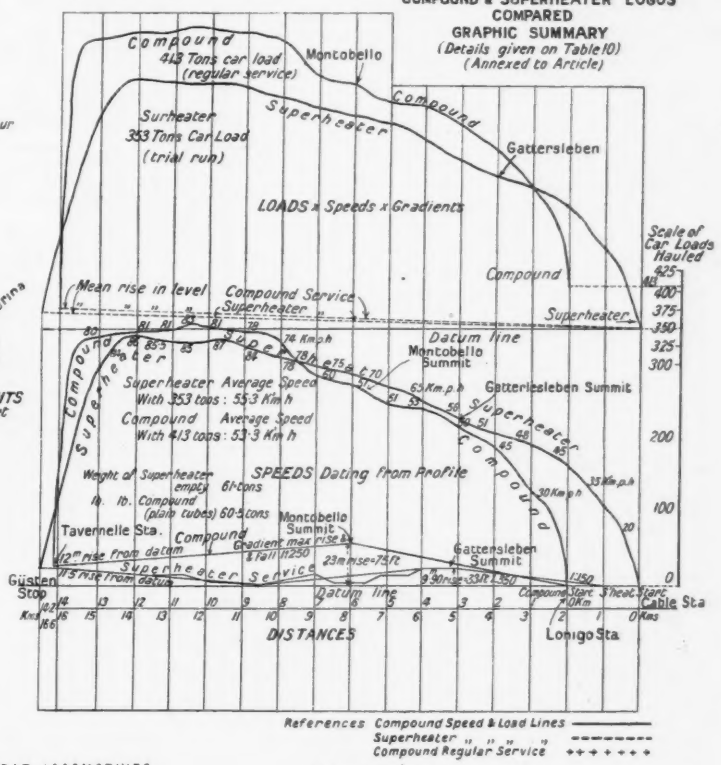
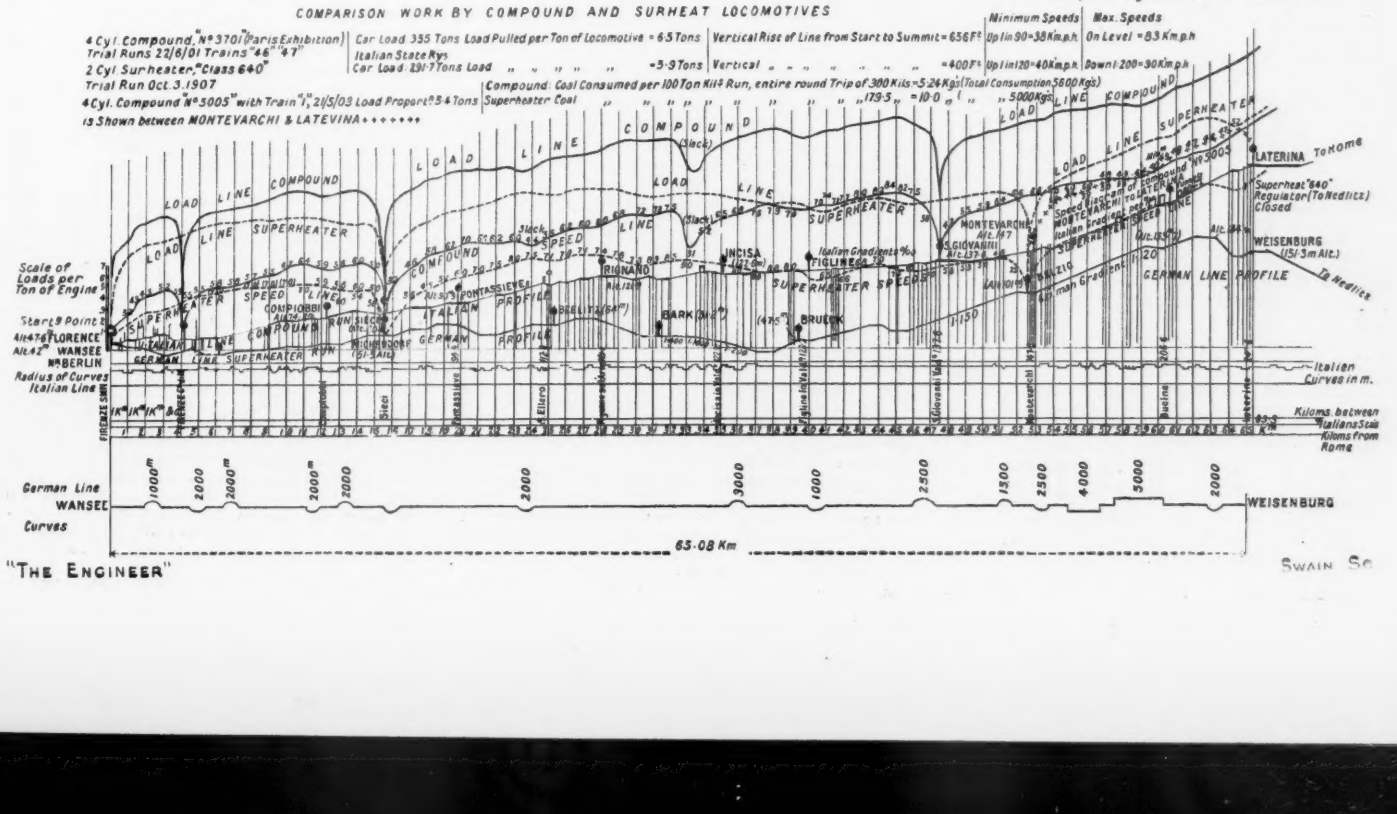


FIG. 3.
DIAGRAM. 10A. THE PRACTICAL RESULTS OF COMPOUND & SUPERHEATER LOCOS COMPARED
GRAPHIC SUMMARY
(Details given on Table 10)
(Annexed to Article)

COMPARISON WORK BY COMPOUND AND SURHEAT LOCOMOTIVES


4 Cyl. Compound "N° 3701" (Paris Exhibition) Trial Runs 22/6/01 Trains "46" "47"
2 Cyl. Surheater "Class 640" Trial Run Oct. 3. 1907
4 Cyl. Compound "N° 3005" with Train "I" 21/5/03 Load Propart^d 5·4 Tons
is Shown between MONTEVARCHI & LATEVINA
Car Load 335 Tons Load Pulled per Ton of Locomotive = 6·5 Tons
Italian State Rys
Car Load 231·7 Tons Load = 5·9 Tons
Compound: Coal Consumed per 100 Ton Kil^s Run, entire round Trip of 300 Kils = 5·24 Kgs (Total Consumption 5600 Kgs)
Superheater Coal = 10·0 = 5000 Kgs
Minimum Speeds
Max. Speeds
Vertical Rise of Line from Start to Summit = 656 F^t
Up in 90 = 38 K/m.p.h
On Level = 83 K/m.p.h
Vertical = 400 F^t
Up in 120 = 40 K/m.p.h
Down 200 = 30 K/m.p.h
COMPOUND LOAD LINE
SUPERHEATER LOAD LINE
SPEED LINE
LATERINA To Rome
"Superheat 640" Regulator (To Neditz.) Closed
WEISENBURG (151·3 m Alt.)
To Neditz.
GERMAN LINE PROFILE
Italian Curves in m.
Kilom^s between Italian Sta^ns
Kilom^s from Rome
German Line WANSEE Curves
63·08 Km

SWAIN Sc

lines run over in the test trials of the superheater locomotives:—

Reference to Chart, Fig. 1.

	Superheater, Class "640."	Compound, No. 3701.
Weight of engine allowing new "Italian" bogie	49 tons	54.5 tons
Weights of trains hauled	291.7 tons	355 tons
Proportion of train load per ton of locomotive	5.9 tons	6.5 tons
Coal consumed for entire round trip of 179.5 kiloms. superheater, and of 300 kiloms. compound, per 100-ton kiloms. run...	10 kilos.	5 24 kilos.

This amount of the coal consumption by the superheater locomotive Class "640" is given in a very lengthy account of the engine and its results by the Prussian builders of it; that is, 5300 kilos., exclusive of fire-lighting, but inclusive of consumption during halts, for the whole trip.

The figures given by makers interested in the extension of the system may be relied upon as being the most favourable possible. The figures of the compound engine —5.24 kilos. per 100 tons kiloms. run—are taken from an official report printed for private use by the Adriatic railways of Italy. Both German and Italian figures refer to lines having long gradients of 1 in 100, the Italian lines occasionally reaching 1 in 90, and being very much more difficult than the German by reason of continuous short radius curves and many tunnels on the gradients—see Fig. 4. Altogether the service on the Italian lines is by far the more difficult.

It is perhaps unfair to contrast superheater locomotives with compound engines. It is not usual—or has not, hitherto, been—to show the saving of fuel in compound engines as compared with superheater locomotives, but only as compared with single-expansion saturated engines. Instead of confronting compounds with superheater locomotives, they are compared with s.e. saturated engines in the following lists, drawn up from the tri-monthly coal reports of the Italian compound locomotives. This shows that the counterpart locomotive of Class "640," that is, the compounds of Class "600," without superheaters, effect a continuous and regular coal saving of 36 per cent.—representing £36 in every £100 expended for fuel. Obviously, compounds, saving 36 per cent. in fuel annually, do not afford superheater locomotives the same opportunity for favourable comparisons as would do saturated single-expansion engines:—

Two-cylinder Express Locomotives.

	Superheater Class "640." Trial result.	Compound "600." Quarterly result.
Per 100-ton kiloms. run, car load... ...	10 kilos.	4.83 kilos.

All Italian engine coal consumptions hereafter given are from quarterly coal lists.

The actual figures from which results the 36 per cent. fuel economy by the compounds are:—

	S.E. engines. Class "500."	Compounds. Class "600."
Per 100-ton kiloms. run, car load only... ...	7.54 kilos. ...	4.83 = saving 36 p.c.

	S.E. engines. Class "656."	Compounds "600."
Per 100-ton kiloms. car load run ...	9.22 kilos. ...	6.04 kilos. = saving 34 p.c.

In goods (slow piston-speed) service the same "600" engines do not show the same saving by means of compounding.

	S.E. goods engines. Class "290."	Compounds "600."
Per 100-ton car load kiloms. run	6.32 kilos. ...	5.15 kilos. = saving over 18 p.c.

The new enlarged two-cylinder compounds, Class "630," and of which the superheater Class "640" is a further enlargement, give the following results—the average of two different locomotive divisions, Venice and Arcona, in running fast trains:—

	S.E. engines. Classes "552" and "540."	Compounds "630."
Per 100-ton car load kiloms. run	6.89 kilos. ...	4.90 kilos. = saving over 28 p.c.

The single-expansion locomotives, Classes "552" and "540," are very economical machines of their system, usually working with cut-offs of 12 and 13 per cent., and taking any load within their power, at 20 per cent. cut-off (see page 367, October 16th, 1903).

In goods service, on mountain lines with gradients exceeding 16 miles long of over 1 in 40, and working with a continuous, heavy, draw-bar pull, the compound system shows to less advantage, thus:—

	S.E. goods engines. Class "451."	Two-cyl. compounds. Class "730."
Per 100-ton car load kiloms. run	6.84 kilos. ...	5 56 ki os. = saving over 18 p.c.

Turning now to four-cylinder balanced compounds, we find that they are more economical in very heavy mountain traffic than two-cylinder compounds, but are still much more so in express traffic on level lines, thus:—

Mountain Traffic.

	S.E. goods engines. Class "450."	Four-cyl. bal. compounds. Class "470."
Per 100-ton car load kiloms. run	5.37 kilos. ...	4.16 kilos. = saving over 22 p.c.

The last is inferior to the results obtained by Mr. Hughes as the outcome of his test of four-cylinder compounds working at the same pressure as single-expansion engines in the same service. This is here shown:—

	Balanced compounds. L. and Y. Railway.	Balanced compounds. Italian. Class "470."
Economy effected in goods service ...	25 per cent.	over 22 per cent.

In express service the economy of compounding is very notable, especially where four-cylinder engines of very simple design are employed, thus:—

Italian Railways.

	S.E. standard type express engines.	Balanced compounds derived from "3701," now Class "670."
Per 100-ton car load kiloms. run	6.73	4.37 kilos. = saving 35 p.c.

These are the average figures of a long period of service in different locomotive divisions: Verona, Bologna, and Florence, and may be taken as representing the average annual saving of £35 in every £100 expended for fuel supplies. They are not the figures of the last few years. To obtain information on their fuel expenditure since 1903 we may refer to the recent report by Mr. L. Greppi, chief engineer of the locomotive and rolling stock testing department of the State Railways at Rome:—"We know from an experience of five years with the 'Adriatic' type balanced compounds that these engines, hauling express trains, whose average yearly load varies between 200 and 350 tons, consume an average of 13 kilos. per kilometre, or only 5 per cent. more fuel than is burnt by our single-expansion engines whose loads have averaged 100 tons less, while the latter have required frequent pilotage." These remarks fully confirm the economy of 35 per cent. realised during the first year or two of service, the load being 60 per cent. greater and the consumption 5 per cent. more with the compounds.

In all countries of the Continent—Prussia, South Germany, Austria, France, and Belgium—the gain by double-expansion is a most important one, and without involving any extra complication that does not exist in single-expansion engines having the same number of cylinders; the number of engine parts being precisely the same in both cases, since a two-cylinder compound engine without starting valve differs in no way from so-called "simple" engines except in the different diameters of the two cylinders.

With superheater engines a very complicated and very costly boiler is necessary. Austrian engines fitted with Schmidt apparatus cost 8500 kronen, or £340, per engine extra. Royalties range from 1000 marks to 650 lire per application. The weight of engines in some instances becomes two tons heavier in boilers for the same steam pressures. Thus:—

Belgian Locomotives (4 cylinders).

	Superheater. No 3303.	Non-superheater. No. 3302.	Compounds. Class "19."
Weights empty ...	76 tons ...	74 tons ...	69 tons

All these engines are of the most approved type of modern express balanced locomotives, all practically of the same construction and power, and intended, originally, to show which system was the most advantageous. The idea of comparing No. 3303 with the class "19" appears to have been dropped, and the greatest reserve is now maintained as to the comparative results. All that is admitted is that:—

"It has been recognised in current service that the four-cylinder non-compound engine is less economical than the compounds."

While comparisons are avoided with modern balanced compounds, abundant information is freely given to show the superiority of the superheater engine over the de Glehn "Atlantic" type, of the class which was tried over here also, the results being as here stated:—

	Four-cylinder superheater No. 3303.	G.W.R. ordinary two-cylinder locomotives.
de Glehn "Atlantic."	Trial result.	Service result.
0	5 to 11 per cent. economy per horse-hour	... 8 per cent. saving

The foregoing figures do not show anything particularly remarkable in the results from the only modern high-pressure four-cylinder non-compound, saturated and also superheated, locomotives that have been tried experimentally on the Continent, and which, I do not think, are likely to be repeated in regular practice.

In France an impartial trial of superheating gave the following results, of which the first line has already appeared in a French review, and in a catalogue:—

Paris-Orléans Railway Locomotives.

American locos. without superheater.	Same with Schmidt heater. Fortnight's test.	Compounds, Class "3000."
Saving... ... 0	16 per cent.	24 per cent.
Present saving— ... 10 to 12	,, ...	—

The saving by the compounds was 8 per cent. greater than the 16 per cent. of the superheater. The results by the superheater were considered to be very good and the economy high, by comparison with the very wasteful consumption of the engines before fitting with superheaters, but that a similar application to the already efficient French-built simple engines would not give a correspondingly high economy. It is obvious that the best results credited to superheaters occur when saturated steam boilers are either designed in such manner, or worked in such manner, as to cause abundant priming, and when such defective conditions are compared with carefully worked superheater locomotives.

The above figures of compound economy are corroborated by the average of ten years' working of the first, and only, purely de Glehn engine built in France, the noted No. 701, which, working at the same pressure as equal-sized non-compound engines—the equally celebrated and efficient "Outrance" simple engines of the Nord Railway—saved 15,410f. in 570,890 kiloms. run, in using coal costing 15f. per ton, the actual figures being:—

	Non-compounds.	Compound "701."
Per kilom. run ...	10.4 kilos. ...	8.6 kilos. = saving over 17 p.c.

The Nord engineers reported as follows in 1900:—"These results show that the compound system is economical at moderate pressures, 147 lb., and that, in consequence, its advantages have not as a condition, *sine qua non*, the use of high pressures."

Low pressures have been shown by Professor Goss to be contributory to fuel economy down to 160 lb., from which it results that, if his tables are correct, a certain amount of the fuel saving must be attributed to pressures not descending below 160 lb., and, *per contra*, a certain extra fuel expenditure must be attributable to pressures above and below that figure.

Fuel economy by means of compounding at low pressures has been the common result of practice for twenty years past. The mechanical means of compounding are very simple. If a large boilered superheater engine is to be converted to compound working, the superheater tubes are withdrawn and replaced by ordinary tubes, the gain in heating surface largely compensating for the removal of the superheater. The various accessories are also cleared away and one of the large cylinders replaced by another of smaller bore, so reducing engine weight and diminishing the surface of cylinder walls and the heat losses due to their greater heat radiation. If it is a small-boilered saturated engine to convert, the usual process is to fit one larger cylinder. In either case the number of moving parts in the engine motion and valve gear remains unchanged. The simple outcome of the changed method of working will vary from 10 to 35 per cent. fuel saving, according to the individual skill of the designer, all other things being equal.

These examples make clear the fact that there is no complication in compounding, the list of parts for either single or double-expansion engines being the same in each type, although cases exist where the simple engines have more working parts than compounds.

The misunderstanding of facts being persistent, it is desirable to give one good illustration of the mechanical position of various engines. German and Austrian examples are here shown:—

	S.E. saturated engine.	S.E. superheater.	Simple compound.
Cylinders	2	2	2
Small A } Large B }	A. A.	B.B.	A. B.
Engine motions... ...	2	2	2
Valve mechanisms ...	2	2	2
Steam pipes	2	2 ... 1, and receiver	2
Boiler	1	1	1
Extra parts...	—	1 superheater	—
Extra parts...	—	Valves controlling smoke tube stifters	—

An addition of this list of parts for each engine will reveal which engine has the greatest number. As regards size of cylinders the two "B.B." of the superheater equal in volume, approximately, the two "A/B" of the compound. As there is no mechanical complication in the compounds it may be averred that the two-stage expansion is in itself a complication. But this complication in the movement of the steam itself results in up to 36 per cent. economy—a decided advantage. Again, it will be urged that compounds cannot start quickly. The reply to this is to be found in an examination of the acceleration curves of the compound locomotives in our diagrams—further remark is superfluous. It is sometimes asserted that compounds are heavier, more costly to build, and dearer to keep in repair. As to the weight, compound engines are built which do not weigh ½ ton more than sister-built non-compounds with the same boiler pressure. Take, for instance, goods engines Classes "1002" to "1005" Eastern of France Railways. Of the same weight and built in the same lot their price per pound is the same, but the compounds save so much coal, that, after a period of fifteen years' very rough service it is still necessary with the engines mentioned to keep their coal lists separate, the latest annual returns—1907—still showing 14 per cent. coal economy, and the enginemen of the compounds gaining less in coal premiums because of the higher coal saving capacity of the compounds. Both simple and compound engines have the same number of working parts. If the compounds were to be converted for single expansion there would be no saving in weight, in number of parts, in boiler pressure, or in simplicity: there would be at once increase of coal consumption by over 14 per cent.

Of the more costly maintenance of compounds an excellent authority has already shown your readers that on the Prussian State Railways, under his control, single-expansion engines only run 23,500 miles between consecutive repairs, while compound engines run 29,440 miles between consecutive repairs, these being the averages of ten locomotives during about eleven years of service. The greater approximation of the average piston effort to the maximum piston effort is the principal saving in wear and breakage with any form of compound motor; and the fact that, in the cylinder of compound engines which is subject to the highest pressure, the piston rings may be used longer without the same steam losses by leakage, and that the piston rings of the low-pressure cylinders are not subject to such heavy pressures as in single-expansion engines is a very simple reason why compound engines should be, as they have been proved to be, less costly in repairs.

In conclusion, it is to be noted that though superheated steam boilers give neither the economy in coal nor introduce any mechanical advantages such as are realised every day in the service of compound engines, it by no means follows that superheater boilers are not advantageous applied to any form of motor—compound or non-compound. Fifty years ago headings "Compounding or Superheating?" attracted notice then as now. Forty-five years ago high superheat locomotive superheaters of the double-bend U type were commonly designed for locomotives. The same form of elements were introduced by the father of railway locomotives, in 1832. Tubular superheaters were introduced in 1768. The principle of superheating was experimented with in the year 1705. The experience of 140 years has demonstrated its utility, whilst it has also shown that superheaters introduce risks of breakdown of considerable gravity, and exact unremitting care and attention, or otherwise become inefficient. On the contrary, double-expansion engines are much more flexible under variations of boiler pressure, and the mere decreasing or increasing of the diameter of one cylinder in a pair involves no such constructive complication as do boilers with superheaters.

RECONSTRUCTION OF A PORTION OF THE CANADIAN PACIFIC RAILWAY.

THE Canadian Pacific Railway crosses the Rocky Mountains at a point where the range is comparatively narrow, but makes up for this fact by its broken character and the height of its peaks. Thus, while the mountain section is shorter than on some of the United States Railways which cross the "Rockies," it presents some of the grandest scenery—as may be appreciated from the engravings on page 672—and the greatest engineering difficulties of any of the lines to the Pacific Coast. This piece of line lies between the towns of Field and Hector, the station at the latter being at an altitude of 5207ft. It is a mile from the top of the incline. The station at Field is several miles to the west of the incline, and here some dozen heavy pushing locomotives are kept with steam up as auxiliaries in the work of pushing the heavy east-bound trains up the incline towards Hector. The incline, it may be remarked, is known by the name of the "Big Hill." It is nearly four miles long, and in it are gradients as heavy as 1 in 22 and 1 in 25. It is no uncommon thing for four or five engines of the 2-8-0 type to be engaged in hauling and pushing one train up it; and the rate of progression is barely six miles per hour.

As showing the opinion locally of this small piece of railway, we propose to quote *verbatim* from a recent issue of the *Daily Province*, which is published in Vancouver, British Columbia. The picturesqueness of the language contained in this local newspaper brings the difficulty of working the line vividly before the mind's eye:—

"How much in dollars and cents it has cost the Canadian Pacific Railway to operate this little stretch of four miles of line, where the rails mount upward at the rate of approximately four and a-half in every hundred feet, it would be interesting to know; certainly it is the costliest piece of trunk line road to pull trains over in North America.

"Some idea of the cost of operating trains on the 'Big Hill' is thrown into the brain-cells of wondering patrons of the railway as they are dragged up the long incline—half-consumed coal dust covering every foot of ground in sight in the vicinity of the track, the deposit varying in thickness from 6in. to 2ft.

"In the course of twenty-four years that charred *débris* has been thrown high in the air through the stacks of countless locomotives panting and snorting as they bent under the herculean task of lifting their loads to the top of the ever-dropping metals.

"By the time the dust of the big sand-glass has buried the year 1908, the 'Big Hill' will have been, metaphorically speaking, torn down, though not entirely obliterated. The grade will have been cut in half, the steepest portion of it not running over 2.2 per cent. At the present time almost a thousand men are toiling at the undertaking of robbing the Rockies of the great toll which they have exacted in railway working costs ever since humans bound their sides with bars of steel, pinning down the hills that the commerce of the world might slip across."

The foregoing is taken from the issue of the *Daily Province* of September 12th last, and it would seem that the estimate of when this great work would be concluded was somewhat optimistic, since the Canadian Pacific officials themselves do not think that the new line will be in operation till February next. How great are the physical difficulties to be encountered in making the new diversion is well illustrated by the various engravings which we reproduce on page 672. One of these, Fig. 5, is a view looking eastwards from Field up along the Kicking Horse River, beside which the old railway runs, continually climbing higher and higher above it. Mount Stephen, 10,600ft. high, will be observed on the right hand. Another—Fig. 3—shows one of the 1 in 25 inclines in the Kicking Horse Valley which the new line is being made to avoid. Still another—Fig. 4—shows the exact point where the gradients are to be improved. Mount Stephen is again prominent in the background. Fig. 2 on this page gives what is really a bird's-eye view of the new works. The old line is shown by the barred white line, and that which is to take its place by the single and longer line. As a matter of fact, the new line is to be about 8¼ miles long, instead of just under four miles. It traverses three tunnels, the first of 170ft., the second 2890ft., and the third long, and the average gradient is 2.2 per cent. or 1 in 45.45, instead of 1 in 22 or 1 in 25. The accompanying engraving—Fig. 1—gives a plan of the two lines, and a profile of the new road. It will be seen that the two longer tunnels are both helical.

When the original survey for the Canadian Pacific line was made, it was intended that no gradient should exceed 2·2 per cent.. Accordingly, the first survey of the line down the Kicking Horse Valley, westward, placed the incline one-quarter the way up the side of Cathedral Mountain. In order to do this, it would have been necessary to drive a tunnel two miles long through the northerly shoulder of Mount Stephen, just east of the present station of Field. This proposal would have been very costly; moreover, it would have taken a considerable time to carry out. Consequently, the existing line was constructed as a temporary measure, so as to get the rail head through to the Pacific Ocean in the least possible time. The line was built in 1884, and has consequently been in use for twenty-four years. Now, however, with modern traffic, the cost of hauling the exceedingly heavy trains over this steep incline has become so enormous that the company some time ago decided to reduce the gradient by making the present diversion, and to spend 1½ million dollars—nearly £310,000—on the work. In our issue of the 11th December we published a letter from the Canadian Pacific Company, in which reference was made to this undertaking, and we gave an engraving reproduced from a photograph of the actual site of the diversion. We give this engraving again in Fig. 1, so as make this article complete in itself, and because it gives a good general idea of the neighbourhood. Moreover, it shows well the respective directions taken by the old and new lines. It will be observed in Fig. 2 that the two spiral tunnels above referred to are on different sides of the river, which has to be crossed twice on bridges that are only a few hundred yards apart.

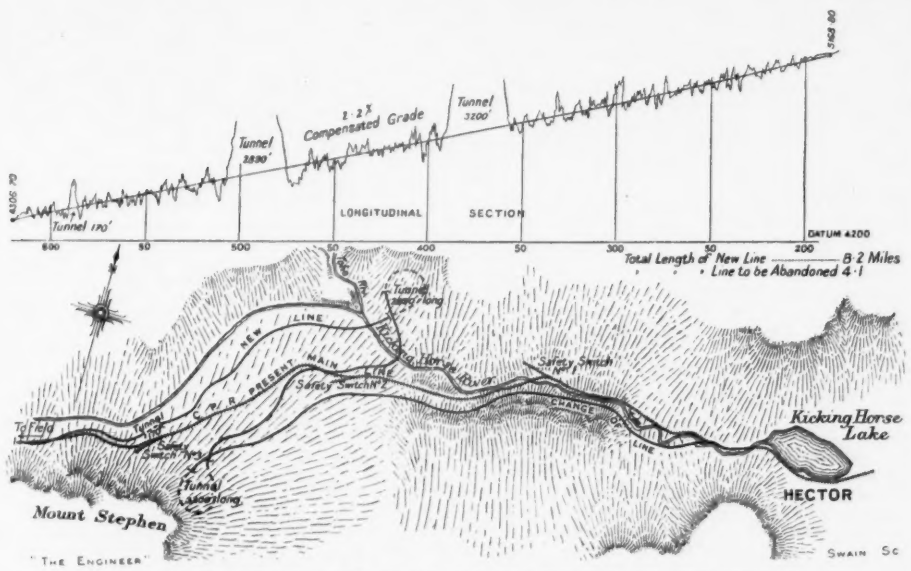


Fig. 1—THE KICKING HORSE VALLEY, SHOWING THE OLD AND NEW LINES

Fig. 2—BIRD'S EYE VIEW OF THE KICKING HORSE VALLEY

The contract was entrusted to Messrs. Macdonnell and Gzowski, of Vancouver, who started the work in September, 1907. To describe the nature of the site we may well quote again from the *Daily Province*, the language of which is certainly calculated to enable a good idea of this out-of-the-way valley to be formed.

"The scene of the work," we read, "was about the wildest, toughest-looking spot it would be possible to find anywhere in the Rockies, which are notorious as having been left by Nature in a badly finished state. What Nature had not done in the first instance to make the work difficult, she had subsequently accomplished by throwing hundreds of thousands of tons of great rocks from the lofty peaks of Cathedral Mountain into the valley below. In past ages the whole northern face of the pinnacled ramparts of this great mountain split, toppled, and dropped off. Boulders weighing hundreds of tons, some of them as large as an ordinary house, were hurled into the valley—and they were all there up-ended, and in defiant-looking bunches waiting for Mr. Macdonell [representing the contractors] when he arrived. The great slide from Cathedral exceeded, in extent and amount of rock displaced, even the enormous disturbance which overwhelmed the town of Frank, Alta, a few years ago."

Such was the nature of the unpromising ground on which the contractors had to work. Some 600 to 800 men have been continuously employed. While the work of clearing was going forward power plants were laid down, these being equipped with boilers, air compressors, pumps, and dynamos. By the time the four portals of the two longer tunnels had been laid bare, 5in. air mains had been laid to them, and the necessary rock drills were on the site. The rock to be traversed was, we may mention, for the most part silicious limestone, and both tunnels were bored from both ends simultaneously. In the first or lower of the two tunnels, boring operations had not been carried very far when soft ground was encountered, this being due to the fact that some small overlying valleys of drift had dipped low enough to be met with. In such places heavy timbering was first of all resorted to, these lengths of tunnel being afterwards lined with concrete. Fissures also have allowed a certain amount of water to find its way into the tunnels, though not, we understand, in any great quantity. It was removed by pumps working just outside the tunnel portals. The tunnels themselves were lit throughout with electric light.

The contractors, before starting to work, thought they would be able to remove all the excavated material by means of hand labour, but it was soon found that this method was too slow to enable the drills to be worked to their full capacity. Four power-shovels—two for each tunnel—were therefore employed, these being worked by compressed air. The tunnels have both of them a radius of 573ft., and the rise in the longer is 48ft., and in the shorter 45ft., the gradients in them being, therefore, less than the average gradient of the whole line. The approaches to the upper portals of both tunnels cross the approaches to the lower portals on solid rock, and there has been no need for high trestle work. Owing to the curvature of the tunnels no triangulating work was done, the driving being carried out in accordance with calculations made every few days by the engineers, who supplied centres and gradients to the contractors.

It is estimated that the operations will have necessitated the removal of some 400,000 cubic yards of rock, as, in addition to the tunnels, some deep spurs had to be cut through. Work was carried on night and day, oil flare lights being used at night. The labour question was to some extent simplified by the fact that more men were drafted into surrounding districts for the harvest than could be employed. For these work was found on the line. Even then, however, it was a matter of no

little difficulty to obtain enough labourers, many of them taking advantage of the comparative nearness of the Pacific coast surreptitiously to board freight trains and make their way there in the hopes of obtaining higher rates of pay and less arduous work.

In spite of the cost of this important piece of work it is certain to pay the Canadian Pacific Railway for having carried it out. The cost of hauling trains over the Big Hill is probably only known to the company's officials themselves, but it must have been enormous. Not only will this expense be largely decreased when the new line gets to work, but it will be possible to run heavier trains at higher speeds. Indeed, it is said that it is proposed to take over the hill trains weighing nearly 1000 tons by means of two 2-8-0 engines, themselves weighing together about 308 tons.

LITERATURE.

Railways and Nationalisation. By Edwin A. Pratt. London: P. S. King and Son, Orchard House, Westminster.

MR. PRATT is one of the few laymen who can write about railways in so free and clear a manner that all who read can understand. His present work is not only timely in that it deals with a subject upon which much light requires to be thrown at the present moment, and especially on what may be called the negative side of the question, but it is absolutely up to date as shown by the quotations from the speeches of railway chairmen made as recently as last August. The author's main purpose is to place the British public in a position to form a more complete judgment on this subject than has hitherto been possible, and to show that railway nationalisation in any of its various forms is unnecessary, undesirable and impracticable, so far as the United Kingdom is concerned.

After noticing that there is a difference between State ownership and State operation, and that the advocates for nationalisation in this country are anxious to operate as well as to own railways, the volume proceeds to gather lessons from those countries where railways are State owned and worked or State owned and leased. The argument by analogy is, of course, not absolutely convincing, for it does not follow that because the State ownership and operation of railways abroad has led to a financial loss, to the introduction of political influences and other fearsome objects that are held up to view, that such would be the case here; it is quite open to any opponent to say that such things would not happen on British railways, and they might justly claim that if these were all the evils that nationalisation could bring, then the proposals were not quite as bad as they had been represented.

But if Mr. Pratt's first line of attack be weak, he has more reasonable and stronger arguments behind. There are the difficulties that would present themselves as to the workshops owned by railway companies, and which would still be required for the maintenance, if not the manufacture, of locomotives, rolling stock, signals, telegraphs, cranes, turntables, &c. &c., and which would thus bring the Government into direct relations with the trades unions, not only of the railway servants, but of engineers, boilermakers, &c. "Even, therefore, if the Government avoided complication with the Amalgamated Society of Railway Servants, they might still be concerned in disputes with some of those other labour unions, or through them be involved in 'sympathy' strikes arising out of troubles in industries with which they had no concern whatever." Then what attitude would the present Government, for instance, take with regard to the Miners' Eight Hours Bill were they the users of about 16 million tons of coal a year, and when an increase of one shilling per ton means £800,000 taken out of their revenue?

The disadvantages the traders would labour under were our railways State-operated are well brought out. It is hardly likely that goods would be carried at express speed except at a higher rate for carriage. In fact, one of the arguments for the change is that, competition being destroyed, fewer trains would suffice. This arrangement, says Mr. Pratt, "would certainly permit of economies being made in working expenses, but it would also necessitate a considerable change in the trading conditions of the United Kingdom, especially as regards the keeping of larger stocks on hand by the trader than is usually done under the present system of practically express rail transport." There would be no facilities for traders in the shape of cheap, if not free, warehousing and wharfage, and no credit would be given, and possibly all "to pay" charges abolished. As to how a trader or passenger would fare if he sent in a claim may be judged from the following remarks:—"Would the position of the traders be improved when they had to deal, not with a commercial company, but with high Government officials who might be less in touch with industrial and commercial developments, might not have the same capacity as trained railway men in dealing with traffic problems, and, even if they were not less sympathetic generally, would be bound by official routine and circumlocution in general? Admitting, for the sake of argument, that the trader has some really well-founded grievances, how would they be likely to disappear entirely under State ownership, or would nationalisation simply produce a fresh crop of a new variety?"

The question as to the workshops for repairing locomotives, &c., has already been noticed in one aspect. It crops up again when Mr. Pratt points out that if the State took them over they would enter into competition with private firms manufacturing rolling stock and railway supplies, and the same issue arises in relation to steamships, docks, hotels, and canals. And what would the Government do on the general question of canals? Would they nationalise them too, as has often been proposed, and "spend a large sum thereon in order mainly to compete with itself as an owner of railways?" Another thorny question is how would the State act towards the municipalities who own electric tramways which rob the railways of their suburban traffic? Finally, on this part of the question, the author quotes some pithy comments of the *Car* as to the State, in its jealousy of rival means of conveyance, making the use of motor cars and motor lorries as unprofitable as possible.

Mr. Pratt, with equal readiness, disposes of the suggestion that State ownership would effect great economies, and then, after dealing with Irish railways—a subject that is being investigated now by a Vice-regal Commission—he suggests some alternatives to nationalisation, which, in his opinion, may be offered with greater confidence to the consideration of the country. These take the shape of amalgamations and agreements such as those now before the public. There will be difficulties, he admits, and the benefits given to the travelling public, "not only . . . without State aid, but in spite of persistent State obstruction and State handicapping in different ways," will be forgotten; but the "average Englishman must see that the railways of his country cannot all go on as they are, and that it will be more prudent on his part to give them sympathetic encouragement in any reasonable organisation of their position they may seek to make, by means of friendly arrangements based on business lines, than to favour a resort to what would be, in the case of the United Kingdom, an essentially quixotic scheme of State purchase and State operation."

Those who oppose nationalisation will find much herein to strengthen them in their views, whilst those who advocate State purchase will be provided with ample food for reflection.

Metallic Alloys. By G. H. Gulliver. (London: Griffin and Co.)

THE enormous amount of scientific work which has been done on the nature of alloys in recent years has led to the production of a considerable number of text-books, and it might perhaps be questioned whether enough has not already been written on the first principles of the subject. The author of this handbook has, however, treated his subject in no stereotyped fashion, but has supplied an extremely interesting, clear, and original outline of the physico-chemical side of the question. The subject matter of the book is stated to have formed part of a course of lectures on alloys delivered in the engineering department of the University of Edinburgh. If the class of students was an ordinary one, probably much of the subject would still be misunderstood when the lectures were finished, and this in itself would afford justification for the publication of the book. But if the students were of a superior type, and already sufficiently prepared, they may well be congratulated on having so complete, so clear, and so well ordered a presentation of the subject. The book may prove disappointing to the ordinary practical man, as it gives no directions for making alloys, no physical or mechanical tests, and no wrinkles which will be of use in the foundry or the workshop. Even the ordinary metallurgical student will probably be surprised at the arrangement adopted in this book, for, instead of beginning with cooling curves, micro-structure, and the phase-rule, the author commences the serious part of his subject with an account of the solution theory and the chemical equilibrium of mixed substances, refers only incidentally to micro-structure in the early portions of the book, and introduces the phase-rule when three parts through the volume. Yet it must be confessed he has succeeded in presenting to students what is probably the clearest and best exposition of the portion of the field with which he treats that has hitherto appeared in the English language. In the anxiety to classify and arrange all the very varied equilibrium conditions which can possibly arise, it may be felt that classification has perhaps been carried to such an extent as to become almost wearisome. Some of the micro-photographs, particularly those relating to iron and steel, might, too, with advantage be improved. The title also, though convenient, is too comprehensive, and might perhaps be expanded with advantage, so as to indicate exactly what the book does and does not include. The author does not afford any evidence of having himself worked at the subjects on which he writes, and appears rather to be a clear thinker and diligent reader than an investigator in this very interesting field. Subject to these few limitations and qualifications, the book can be heartily recommended for use by senior students in Universities and technical schools, and for others to whom a knowledge of this branch of the subject is likely to be of interest or of use.

SHORT NOTICES.

Steel Ships: Their Construction and Maintenance. By Thomas Walton. Fourth edition. London: Chas. Griffin and Co., Limited, Exeter-street, W.C. 18s. net.—Since the last edition of this work was published many changes have taken place in the practice of shipbuilding. It was therefore deemed necessary to incorporate the latest developments in naval architecture in order to bring the book up to date, and to enhance its value as a work of reference. Detailed illustrated descriptions of Isherwood's new system of longitudinal framing; the latest developments in the construction of "turret," "trunk," "single-deck," and other types of steamers are introduced, whilst most interesting and useful information, accompanied by numerous diagrams and illustrations, relative to both launching and the construction of the new Cunard quadruple-screw express turbine steamers Lusitania and Mauretania are also included. The book is profusely illustrated by many excellent half-tones, diagrams, and drawings.

Timber. By J. R. Baterden, Assoc. M. Inst. C.E. (Westminster Series.) London: A. Constable and Co., Limited, 10, Orange-street, Leicester-square, W.C. Price 6s. net.—This is a practical book on timber. Only those timbers have been dealt with which are most commonly used, either in their native districts or in the general timber trade, together with some others, which, in the author's opinion, will come into the market before long. The subject is divided into fourteen chapters, each of the first nine dealing with the timber of some country. In the tenth the author considers the causes of decay and destruction of wood. This is followed by chapters on seasoning and impregnation of timber, defects in timber, and general notes, strength and testing of timber, and "figure" in timber. The book contains a lot of valuable information, which has been obtained in all cases from reliable sources.

Principles of Sewage Treatment. By Dr. Dunbar. London: C. Griffin and Co., Limited, Exeter-street. 15s. net.—This book, which has been translated from the German edition by Mr. H. T. Calvert, constitutes an interesting and useful addition to the literature on the subject. The book is divided into two parts and there are eleven chapters. The four chapters which constitute Part I. deal with growth of river pollution, legal measures taken by central and local authorities, rise and development of sewage treatment, earlier views on methods of sewage treatment: and their object and unity. Part II. is devoted to the present position of sewage treatment, and contains chapters on characteristics of sewage, objects of purification works, descriptions of methods for the removal of suspended matters, methods for the removal of putrescibility, the disinfection of sewage, supervision and inspection of sewage disposal works, and the utility and cost of various methods of sewage treatment.

The Proper Distribution of Expense Burden. By A. Hamilton Church. London: *The Engineering Magazine*, Keanstreet, Aldwych, W.C. Price 3s. 6d.—The contents of this book appeared originally in the *Engineering Magazine* as a series of articles in which the author discussed the fundamental principles of the subject. There are six chapters dealing respectively with interlocking general charges with piece costs; distributing expense to individual jobs; the scientific machine rate and the supplementary rate; classification and distinction of shop charges; mass production and the new machine rate; and apportionment of office and selling expense. The book is written to conform with American ideas and customs. The subject is one which needs careful study, and the clear analysis given by the author will enable the reader to proceed along a well-defined and carefully thought-out path.

Elements of Railroad Track and Construction. By Winter L. Wilson. London: Chapman and Hall, Limited, Henrietta-street, Strand, W.C. Price 8s. 6d. net.—In this book the author puts forward a few fundamental principles in order to give the inexperienced engineering student a general idea of the subject of the construction of permanent way. Consequently it is an elementary book, and does not enter into the more detailed part of the subject, which, the author rightly states, can only be obtained by practical experience. There are nine chapters, in which such subjects are considered as:—Permanent way; turn-outs; side tracks; yards; termini, &c.; maintenance of way; railroad construction; trestles; culverts; and the subgrade. The letterpress is accompanied by a number of carefully prepared small diagrams.

Strength of Materials. By A. Morley, M.I. Mech. E. London: Longmans, Green and Co., 39, Paternoster-row. 7s. 6d. net.—A considerable amount of attention has been paid to the subject of the strength of materials, and there have been many excellent books written on the subject, and it appears difficult to believe that there is room for another. However, the author of the book before us has written a very acceptable work which should find favour amongst engineering students. The book follows the lines of most of the others, and special attention has been paid to the strength of rotating discs and cylinders, the bending of curved bars with applications to hoops, rings, and links; the strength of unstayed flat plates, and the stresses and instability arising from certain speeds of running machinery.

Electric and Petrol-Electric Vehicles. By W. P. Adams. London: C. Griffin and Co., Limited, Exeter-street. 5s. net.—The advent of electric and petrol-electric vehicles has naturally given rise to a desire for knowledge among those who are associated with these vehicles, but are not versed in electrical matters. The present book supplies this want, and deals with the subject in a simple manner. The book is divided into two main sections, the first dealing with the mechanism, and the second with its management. In addition, the author has provided a simple and general introduction on the subject of electricity, more particularly in its relation to the machinery employed on the electric vehicle. The closing chapters describe several of the most prominent systems of electric vehicles, and also the petrol-electric system.

Cassell's Cyclopædia of Mechanics, in five volumes. By Paul N. Hasluck. Vol. I. London: Cassell and Co., Limited, La Belle Sauvage, Ludgate-hill, E.C. Price 7s. 6d. net.—Five volumes of this cyclopædia have been published, and each is complete in itself. The volumes comprise 30,000 items and 6500 illustrations, containing in a form convenient for ready reference and every-day use, receipts, processes, and memoranda, which should prove of value to the handyman and mechanic. There is a copious index, by means of which any specific information with which the books deal may be referred to with the least possible trouble.

Cement Laboratory Manual. By L. A. Waterbury. London: Chapman and Hall, Limited, 11, Henrietta-street, W.C. Price 4s. 6d. net.—Cement testing is fully dealt with in this little volume, that is to say, so far as technical schools are concerned. The author states that it is not intended to give instructions with regard to testing cements for commercial purposes. On closely looking through the book we find all the tests usually adopted fully described, and we consider experience would be the only lacking essential quality of the student to enable him to carry out commercial testing with success. Various forms of apparatus are nicely illustrated, and the descriptions are short and lucid.

Hazell's Annual, 1909. London: Hazell, Watson and Viney, Limited, 52, Long-acre, W.C. Price 3s. 6d. net.—In accordance with the usual practice, the 1909 edition of this book has been revised and re-written to meet the changing needs of the time, and the present volume may be regarded as practically a new book. There are articles on aëroplanes, airships and balloons, cables of the world, smoke abatement, housing and town planning, naval forces of England and Germany compared, old age pensions and regulations, and on many other subjects which are at present to the front.

PETROLEUM RESIDUES AS FUEL ON THE ROUMANIAN RAILWAYS.

ROUMANIA is now one of the world's large producers of petroleum. Last year its output of crude oil amounted to 1,129,097 tons, and although much of this consisted of petrol, benzine, and lamp oil, yet all the rest, with the exception of a small proportion of lubricating oil and paraffin, constituted what are known as residuals. Roumania, like other countries which had preceded it in the business, had not long started on its career as a petroleum producer on a large scale, before it realised that for any

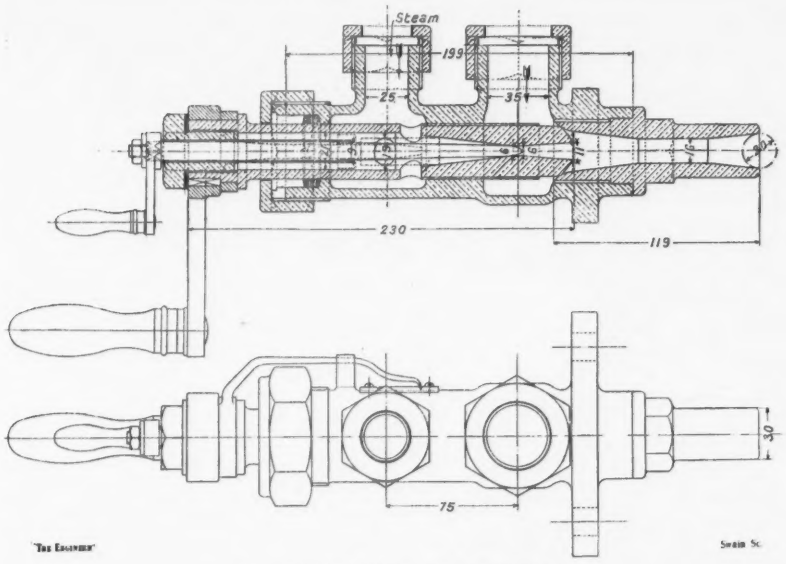


Fig. 1—DRAGU LIQUID FUEL BURNERS

contemplated successful competition with the oils of other petroleum-producing countries, two conditions at least are indispensable; the one being to produce marketable products at a remunerative price, the other condition being the maintenance of a uniformly good quality in these products. The latter condition demands efficient refining, which entails the rejection of a very considerable proportion of the crude petroleum submitted to the refining operations. But to ensure the first condition, these rejected portions—the residues, in fact—must bear their share of the cost of production and refining. They, however, do not lend themselves readily to railway transport over long distances, hence a local use for them becomes most appropriate. Roumania, rising to the occasion, thought of her railways, which were costing her large sums of money for foreign coal or for home-grown wood, to work the locomotives, since the indigenous lignite was neither satisfactory nor convenient for the purpose. Accordingly the residues were tried, and gave every promise of success.

The Roumanian petroleum residues practically consist of those portions of the crude oil that remain undistilled at 250 deg. Cent.; they hence retain very little volatile matter indeed, but they vary in specific gravity between 0.890 and 0.955 at 15 deg. Cent.; they are very viscid below 5 deg. Cent., whilst at 20 deg. Cent. their viscosity is twenty-eight times and at 50 deg. Cent. four times that of water. Their average composition is 86 per cent. carbon, 12 per cent. hydrogen, 2 per cent. oxygen, and their theoretical calorific value 10.356 calories, though they have given 10,500 calories in the Mahler bomb. When these residues, and some of the other fuels available in the country are compared, taking Welsh coal as a standard, 1000 kilos. of the residues are equivalent to 1330 kilos. of the coal, whilst the equivalents for 1000 kilos. of each of the other fuels are:—Westphalian coal, 1000 kilos.; Heraclean coal, 850 kilos.; Roumanian lignites, from 580 to 350 kilos.; a cubic metre of cord-wood=210 kilos. The residues require, theoretically, 14.05 kilos., or 10.88 cubic metres (384 cubic feet) of air per kilo. for their combustion; whereas a kilo. of Welsh coal requires 11.59 kilos., or 8.97 cubic metres (316 cubic feet). But to produce a thousand calories with the latter requires 1.40 kilos., with the residues 1.33 kilos., or 5 per cent. less; moreover, the residues should produce theoretically, by weight, 6 per cent. less products of combustion than the Welsh coal. Traction tests have indicated that a kilo. of the residues can do the work of 1.38 kilos. of Welsh coal.

The Urquhart and the Holden atomisers, with some modifications, have been the only burners used until recently on the Roumanian railways, the former for firing with residues alone, the latter for the use of residues in conjunction with local lignite. However, it has been found that the regulating arrangements for varying the supply of residues to the fire, in these two types of burners, do not allow a sufficiently wide margin to meet the demands of very hilly country without trouble. Hence in Roumania new burners have entered the lists with the idea of overcoming these difficulties. Professor Dragu, of the National School of "Ponts et Chausées" in Bucharest, who is an Inspector-General in the railway service and chief engineer of the Works and Locomotive Department, is responsible for one new burner, and also for an excellent paper on the whole question of the use of residues as fuel in the locomotives on the Roumanian railways, of which, moreover, we have made use in these notes. M. G. C. Cosmovici, who is also an Inspector-General and deputy chief in the same department as Professor Dragu, is responsible for another new burner. The Professor, in designing his burner, has kept in view the requirements of considerable elasticity in the fuel supply; the minimising of the amount of steam used in atomising so as to economise fuel, and the providing facilities for cleaning or removing obstructions even during a run. In the Dragu atomiser the steam enters from the side into an annular chamber, from which it passes through apertures of ample area into a central tube which terminates at the front end in a nozzle. This commences as a diminishing cone, but after reaching a minimum diameter expands to the outlet. A long spindled adjustable conical valve controls this nozzle, being supplementary to the admission valve in the steam supply pipe, and permitting of very exact regulation. The liquid fuel arrives also from the side into an annular chamber immediately behind the mixing nozzle, and surrounding the nozzle of the central steam admission tube. The latter can be caused to recede or advance as desired, and controls the supply of fuel into the mixing nozzle, from which the mixture is directly ejected into the fire-box. The expanding end to the nozzle is calculated to give a considerably increased emission speed in comparison with the Urquhart or Holden burner.

M. Cosmovici's burner is designed in such a way as to encourage an intimate admixture of the air for supporting combustion with the liquid fuel to be burnt, this being effected by causing the air to rush through the cloud of spray on its way to the fire-box. The Cosmovici burner consists of a flat rectangular vessel provided with an enlarged chamber at the back, whilst a shallow depth of the upper portion, extending the whole length and breadth of the vessel, is partitioned off to serve for the admission of steam, leaving the lower portion for the supply of petroleum. The vessel is open at the front, and otherwise closed, but is, of course, provided with various valves, taps, &c., for the admission of fuel and steam, and for draining and blowing out, for the passage of the spindles of regulators, &c. The front of the vessel has a machined surface, for the purpose of making a good joint with the nozzle, which is bolted on to it. The nozzle is divided by a horizontal partition into a steam and an oil chamber, corresponding with those in the main vessel; and opposed to the oil orifice are six circular ports, controlled by conical plugs, which communicate with six radiating channels separated by webs. The under part of the nozzle curves up towards the front, so that these channels terminate at a horizontal surface where the openings are trapezoidal, are separated by projecting ribs, and are arranged in an arc of a circle. The steam chamber of the nozzle remains level, but contracts towards the front, and at the outlet presents a narrow slit corresponding exactly with the level of the top of the fuel orifices. Hence, when at work, under the directing influence of the raised ribs, six steam jets are formed, all of equal size, which, on escaping from the nozzle, spread like a fan, carrying the atomised petroleum with them. A thin sheet of very broad and long flame is consequently produced which covers the entire surface of the grate, and presents a complete screen through which the air from below must pass on its way to the fire-box. This tends to secure the effective admixture already referred to, as well as efficient combustion, and that, with a minimum amount of air. The arrangement has the advantages of requiring no admission of undesirable cold air to the fire-box, and of demanding but comparatively little steam. For the regulation of the supply of petroleum in this burner each oil orifice where the nozzle is attached to the main vessel is furnished—as already observed—with a conical plug connected to a spindle passing out at the back of the main vessel, so that each plug can be pushed forward or drawn back independently, and the discharge from each jet be regulated separately. A wedge-shaped plug operated by a lever at the back of the vessel serves a similar purpose for the steam admission. There are arrangements for scouring out and draining the oil chamber, and a scraper fitted in a frame, worked from a lever at the back, to clear the jets and intervening ribs from soot, &c. Quite a number of Dragu burners and a few Cosmovici burners have been fitted to working locomotives in Roumania. The arrangement of the atomisers, the fire-box, and accessories on Roumanian locomotives is shown in Figs. 3 and 4, the former showing the condition of things when solid and liquid fuel are both used, the latter when liquid fuel is used alone. The large amount of brickwork in the latter case serves, when the air inlets are closed—as they should be—as a reserve of heat when the fuel supply is shut off while going down inclines or stopping at stations, and this prevents the various inconveniences that would arise from any sudden cooling, which is obviated in the mixed fuel locomotive by the fire of solid fuel kept alight on the grate. The use of compressed air for atomising has been duly considered, and as a result of comparing the advantages with the disadvantages, the Roumanian engineers have decided in favour of the retention of steam for the purpose. In regulating the supply of fuel and steam, the engine-driver is guided by the appearance of the smoke from the funnel and of the flame. The smoke ought not to be quite white, as that indicates too large an excess of air. The flame ought neither to be red nor too white, if incomplete combustion is to be avoided on the one hand and local concentration of heat on the other. The firing is started as usual by means of live steam from another locomotive, hence all the liquid fuel locomotives are furnished with pipes and cocks

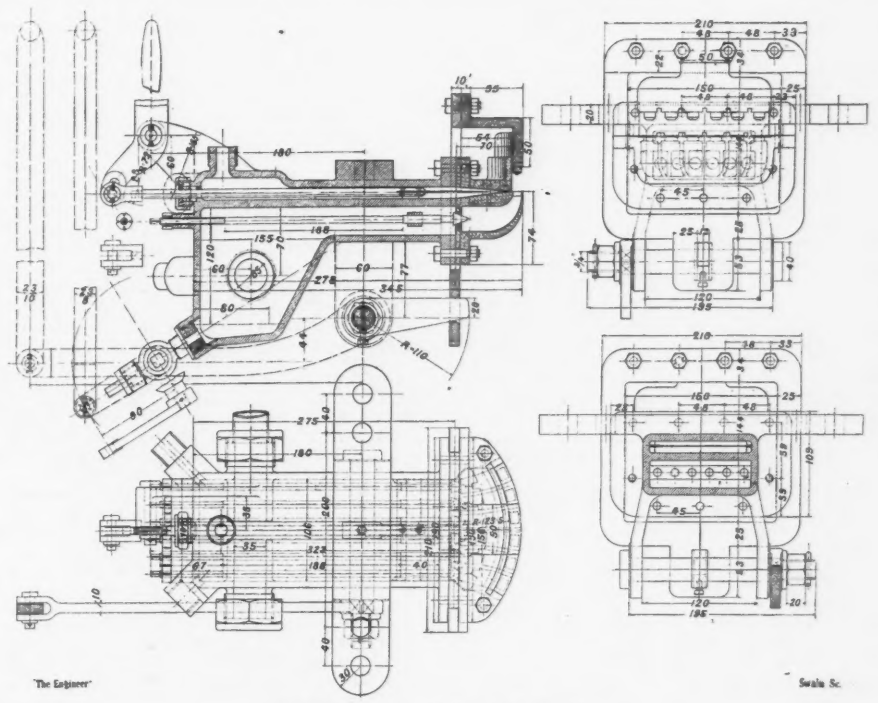


Fig. 2—COSMOVICI LIQUID FUEL BURNER

for the purpose, as well as with steam coils and connections for warming the oil in the tender, as otherwise, in cold weather, it is liable to get too viscid and upset the working of the engine. Equipping a locomotive and tender in Roumania with liquid fuel appliances costs £100 for all-liquid firing, and £80 for mixed firing. To ensure the regular supply of fuel two classes of reservoirs are employed, those of the ordinary well-known above-ground type made of mild steel plates, and ranging in capacity from 200 to 2800 cubic metres (7063 to 81,224 cubic feet), serve as storage tanks, whilst others, also

USE OF PETROLEUM FUEL ON ROUMANIAN RAILWAYS

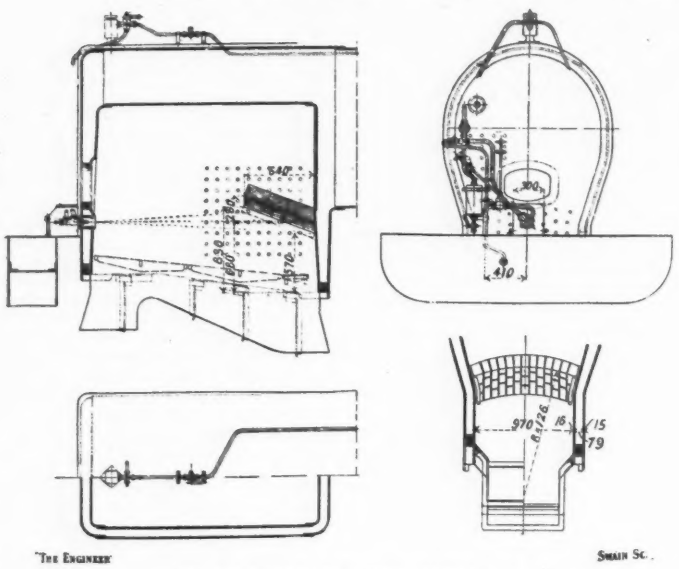


Fig. 3—FIRE-BOX FOR COAL AND OIL

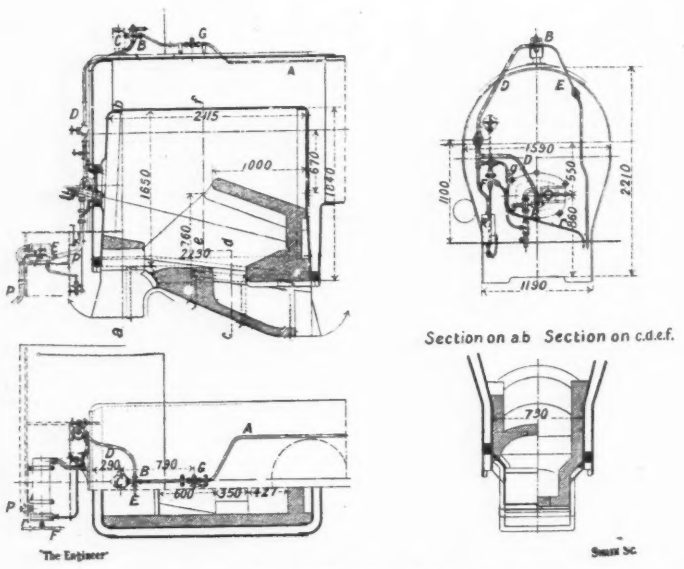
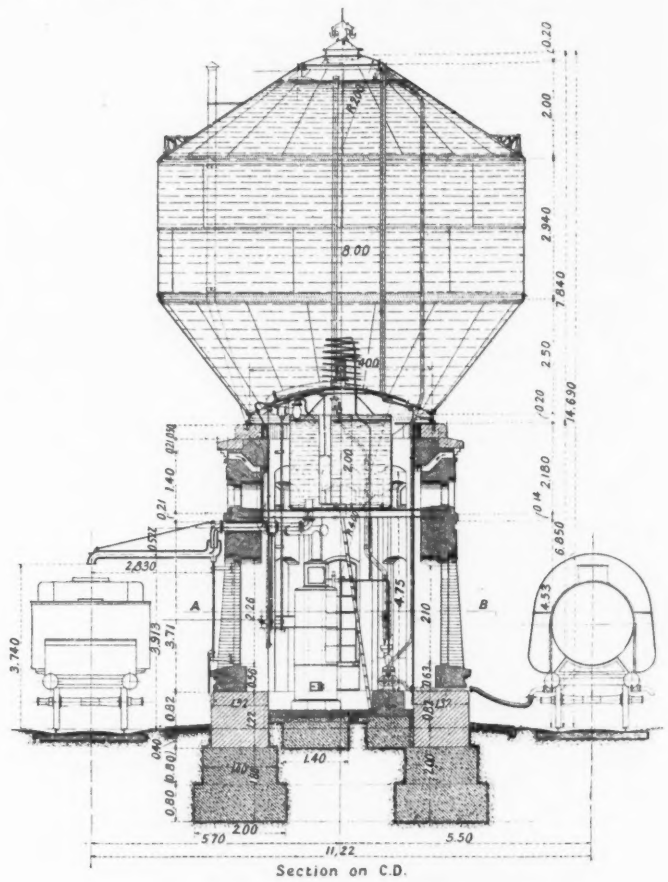


Fig. 4—FIRE-BOX FOR OIL



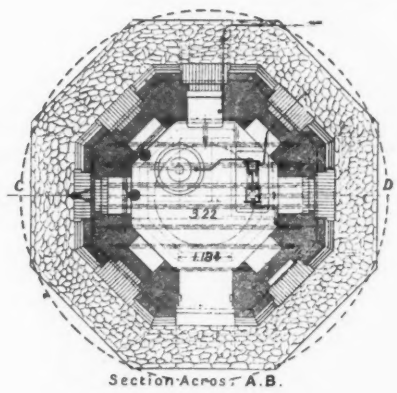


Fig. 5—OIL TANKS

constructed of steel plates but supported on masonry towers, to enable the oil to flow by gravity into the tenders, serve as distributing tanks. They are constructed in three sizes, 66, 100, and 260 cubic metres (2330, 3530, and 9181 cubic feet), and are furnished with various accessories, such as a pump for transferring the oil from or to the tank wagons, or from one tank to another, steam coils for heating the oil in winter, arrangements for gauging the quantity furnished to the locomotives, &c. —Fig. 5. At small stations the distributing tanks also serve as storage tanks. In Roumania the tank wagons are of 15 tons capacity, and they are provided with arrangements for heating by means of direct steam, as a steam coil is not found sufficient for the purpose; the water which condenses collects at the bottom, and is drained off from time to time.

The Government specify that the oil supplied for fuel shall contain no benzine, no illuminating oil, no crude oil, nor water, acids, alkaline matter, soil, or sand, &c.; that its specific gravity shall be between 0.890 and 0.955 at 15 deg. Cent., and that its flash point shall not be lower than 80 deg. Cent.—176 deg. Fah.—and they reserve to themselves the right of inspecting the factories supplying the fuel. It is noteworthy that while in 1896 2233 tons of residues were consumed on the railways; that factor has now risen to considerably over 300,000 tons; last year it was 332,990 tons. The subject received attention at the Petroleum Congress held in Roumania last autumn, when Professor Dragu's paper was presented.

PROGRESS OF WARSHIPS AND MACHINERY UNDER CONSTRUCTION IN ENGLAND.

During the last six months or so the progress of war shipbuilding has been as follows:—The battleship Bellerophon, built at Portsmouth, and engined by the Fairfield Shipbuilding and Engineering Company with turbines to develop 23,000 horse-power and drive the ship at 21 knots, left that port on October 26th for her steam trials. At four-fifths, or 18,400 horse-power, a speed of 19 knots was realised, and on the eight hours' full-power trial a speed of nearly 22 knots was attained, or one knot more than the contract speed, a result which was considered highly satisfactory, as was also a subsequent series of trials with the cruising turbines. The whole of the ship's official trials were completed by the 24th of November, and as she was laid down on the 3rd of December, 1906, she will have been completed for "fighting" purposes within the two years allowed for her construction.

The armoured cruiser Boadicea, built at Pembroke—which was fully described in our article of July 10th—will not, it now appears, be completed for sea as soon as was at first intended. The basin trials of her turbines were carried out during this month, and the contracting engineers have made every effort to have her ready for her official steam trials by the end of the year.

The engines of the armoured cruiser Defence during the thirty hours' trial—in very rough weather—at one-fifth power, worked very smoothly, and gave better results than those concerned anticipated. 23.4 knots were attained in the eight hours' full-power trial, and 19.25 knots on the measured mile trial at four-fifths power. The acceptance trial of the machinery will not, however, take place until early in the new year.

The battleship St. Vincent, built at Portsmouth, was launched on the 10th of September without the slightest trouble, in spite of the great launching weight of over 7000 tons. As a large quantity of material, in the shape of machinery, for her has already arrived at the dockyard, there will be no loss of time in getting on with the work to be done upon her.

Remarkably good progress has been made with the battleship Collingwood at Devonport, although the engineers' strike was credited with a forced postponement of her launch. Nothing unforeseen, however, occurred to prevent her taking the water on the pre-ordained day—November the 7th. Her launching weight was 500 tons more than that of the St. Vincent.

As the first class cruiser Indomitable, which made the trip to Canada and back, with his Royal Highness the Prince of Wales on board, was not fully completed when she left England, the contractors are now engaged in finishing her, which means the entire removal of all the special "fittings" placed on board for the convenience of his Royal Highness, and preparing her for the commencement of the new duties she is intended to take up.

Of the new warship construction in the Royal Dockyards commenced within the past six months, the first to record is that of the armoured cruiser Bellona, laid down on the 1st of July at Pembroke Dockyard. She will have a displacement of 3350 tons, and be fitted with turbines of 19,000 horse-power, which are expected to give her a speed of 25 knots an hour. Since being laid down, her progress has been very satisfactory, more work having been done on her than on any previous ship of her size in the same time.

An improved Indomitable, to be named the Indefatigable, is to be laid down early in the new year at Devonport, on the "slip" lately vacated by the battleship Collingwood. She will be a considerable advance in all respects upon her predecessors of the Invincible class; and so far as the prime requirement in a modern warship is concerned, viz., speed, she is expected to outstrip all previous ships of her class or type. That no armoured cruiser now being built by any other Naval Power (than our own) will compare with the new ship, may be safely affirmed, by the following leading particulars about her, which are now known. She will have a length of 570ft., a beam of 79ft. to 80ft., and a displacement of 18,000 tons. Her propelling machinery is to develop 45,000 horse-power, and is designed to give her a contract speed of 28 knots, which may, judging from past experience with ships of great length and high power, be exceeded by a knot or two. The slip is being lengthened to accommodate her.

A new battleship, to be named the Neptune, is also to be commenced at Portsmouth Dockyard early in the coming year. She will be the largest and most powerful warship of her class that has yet been built for the British Navy, as she will have a length of 510ft., with a beam of 86ft., and a displacement of some 20,000 tons, or about 750 tons more than the same type of ship—the St. Vincent—lately launched from the same dockyard. The propelling engines of the Neptune are to be of the turbine

type, and of about 25,000 horse-power. That a good start in the construction of the ship is to be made is evidenced by the large quantity of material for her which has already been received at Portsmouth, and it is intimated that the ship is to be ready for sea within two years from the date of her commencement. To facilitate this the contract for the construction of the turbine engines for the ship has been placed with John Brown and Co., Limited, of Clydebank, and the boilers and other machinery will be supplied by Harland and Wolff, Limited, of Belfast.

An interesting event was the trial of the Rattler, an old British gunboat, with a single screw and a displacement of 720 tons, built at Elswick in 1886. Her steam engines and boilers were removed and a single set of vertical gas engine and producers put in their place. The trials were fairly satisfactory, but there is still much to be learnt about gas propulsion before steam is likely to be displaced for large powers.

Turning now to the progress made in the construction of warships and machinery in the private shipyards and engine works in England in the past six months, we find that during that interval at Elswick the armoured cruiser Invincible, having completed all her official trials in a very satisfactory manner, is now being got ready for handing over to the Admiralty; the battleship Superb is now nearly ready for her official trials, which will take place about the beginning of March; the Argentine gunboats, Parana and Rosario, are now nearly complete, excepting for their armament, which will shortly be placed on board. The usual mooring tests have already taken place, and it is expected that these vessels will proceed on their trials early in the new year. The Brazilian battleship, Minas Geraes, launched on September 10th, is now making rapid progress, all the machinery and armour being in place. The Scouts Bahia and Rio Grande do Sul, also for the Brazilian navy, are well advanced on the stocks; the former will be launched next January, and the latter about two months later. It is anticipated that an early commencement will be made with the construction of the new second class protected cruiser on order for the British Government.

Hawthorn, Leslie and Co., Limited, have, during the past six months, or since the ending of the engineers' strike, completed the 33-knot torpedo-boat destroyer Ghurka, which has been handed over to the Admiralty. The Afridi, a similar vessel to the Ghurka, built at the Elswick shipyard, is expected to resume her trials—interrupted by the strike—early next week. The trials of the first-class torpedo boat No. 21 built at the Hebburn shipyard, have been successfully carried through, and the machinery is now being opened out for official examination, before the vessel is handed over. The similar class torpedo boat No. 22 has been steamed at moorings, and will, it is hoped, proceed on her sea trials immediately. Work at high pressure (since the conclusion of the strike) has been resumed on the battleship Temeraire—built at Devonport Dockyard—all the machinery being now on board the vessel. Steam will be raised in some of the boilers at the beginning of January, and the engines tried at moorings by the end of that month. The programme of official trials has been arranged so as to commence them in the middle of February. Work on the machinery of the first-class torpedo boats Nos. 33 and 34—now being built at the Hebburn shipyard—is in full swing, the boilers being already finished and on board. All the material for the turbine machinery of the first-class battleship Collingwood at Devonport is now in the shops at St. Peter's Works, and its machining is being pushed forward with all possible speed. Six of the boilers are water tested and finished, and are being mounted, with a view to despatching them to the vessel, and the remaining twelve are in an advanced state. The work on the machinery of the 33-knot torpedo-boat destroyer Zulu has just been resumed, as all the material is on the premises. The Admiralty having placed an order for a 27-knot torpedo-boat destroyer with the firm—to be built at the Hebburn shipyard—work in connection with it in the drawing-office has just commenced.

Palmer's Shipbuilding and Iron Company at Jarrow has, during the past half-year, completed and delivered the first-class battleship Lord Nelson to the Admiralty, for whom the firm has also in hand three first-class torpedo boats—one of which is in the water—and the ocean-going 33-knot destroyer Viking.

Passing from the Tyne to the Thames, there still being no warship work on the Humber, we find that at the only shipbuilding works now left in London—the Thames Ironworks Company—an order has been placed by the Admiralty for one torpedo-boat destroyer.

At the shipbuilding and engineering works of John I. Thornycroft and Co., Limited, at Woolston, Southampton, the progress during the last six months has been as follows:—The 33-knot destroyer Amazon ran her official speed trials at Skelmorlie on October 20th last, and attained a speed of 33.73 knots on the measured mile, and 33.21 knots during a continuous run of six hours. She will be handed over in the course of a few weeks. The Nubian—a similar vessel to the Amazon—is being brought forward for launching early in the new year. The first-class torpedo boat No. 20 has been completed and handed over to the Naval authorities. Two other similar topedo boats—Nos. 31 and 32—are both nearing completion. No. 31 has carried out all her steam trials satisfactorily at Stoke's Bay, attaining during the eight hours' trial a speed of 26.437 knots. No. 32 is preparing for trial. All the above-named vessels are adapted to burn oil fuel, and their turbine machinery and water-tube boilers have been constructed at the Southampton works. An order for one of the new 27 knot destroyers has been received from the Admiralty, but work upon her has not yet begun.

At Yarrow and Co., Limited's works, Scotstoun, Glasgow, of the ten sea-going destroyers on order last June for the Brazilian Government, the first two have passed all their official trials, and easily attained the contract speed of 27 knots, carrying a load of 100 tons. These vessels are 240ft. long by 28ft. in. beam, steam being supplied by two Yarrow boilers fired at both ends, which have been very successful. The first of these vessels is now on her way to Brazil, and the second has been handed over. The third is running her trials, and the fourth has just been launched. The remaining six are well in hand. These Brazilian destroyers are very completely fitted, having refrigerating apparatus for keeping the magazines and cabins cool, wireless telegraphy, and a small motor dinghy.

A shallow-draught gunboat, 120ft. long by 20ft. beam, for the Portuguese Government for service in Macao, is also in hand at Yarrow's works. This is now practically completed.

There has also been constructed at Scotstoun since last June a torpedo boat 100ft. long, propelled by internal combustion engines, which has given very satisfactory results on trial.

Cammell, Laird and Co., Limited, of Birkenhead, since their last return in June, have little to report, except that the ocean-going destroyer Swift, built by them, has not yet completed her trials, and that they have received a provisional order from the Admiralty for three of the new 27-knot destroyers.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

FOUR-CYLINDER NON-COMPOUND EXPRESS LOCOMOTIVES.

SIR,—With your kind permission I will reply to the letter on the above subject which appeared in your last week's issue. Your correspondent "Argus" makes some very bold statements.

In the first place, I was not aware that the results of any tests had ever been published as to the economy of four-cylinder compound *versus* four-cylinder non-compound locomotives.

I am astonished when he says that high-speed compounds effect an economy of 32 per cent. as an average.

Will he kindly favour us with particulars as to where the tests were carried out, and under what conditions?

My reason for believing that the four-cylinder non-compound express engine will probably become a standard type is based upon a close study of the subject for many years.

Let us see what object is aimed at by compounding.

The answer is:—"To expand the steam and reduce the terminal pressure." Now, I have seen indicator diagrams taken from single-expansion express locomotives when running fast, which prove conclusively that the pressure at the end of the stroke is very little, if any, higher than that of the atmosphere. What more could be gained by compounding? The terminal pressure in a single-expansion engine is bound to be low if the speed is high. Steam cannot get through the ports quick enough to keep up the pressure, and must therefore be expanded. We have here conditions practically the same as those accruing from compounding.

Your correspondent also says that no duplicate reversing gear should be fitted to "mar" the results. This sounds rather queer, in view of the fact that the late Mr. F. W. Webb's four-cylinder compounds on the London and North-Western Railway were very sluggish engines till Mr. George Whale improved them by fitting duplex valve gearing. It is well known that this alteration has considerably increased their efficiency.

Your correspondent further informs us that compounds are faster than single-expansion locomotives. Are they? I cannot do better than quote from the records of the late Mr. Charles Rous-Marten, who was undoubtedly the greatest authority on the subject of railway speeds. Mr. Rous-Marten timed hundreds of runs with compound locomotives, and the highest "compound record" stands to the credit of the French Northern Railway, when, on one special occasion, a speed of 90.2 miles per hour was reached for a short distance.

Now for some speed records with single-expansion locomotives. Mr. Rous-Marten has recorded speeds of 90 to 91.8 miles per hour on the Midland, London and South-Western, London, Brighton, and South Coast, and Great Central Railways, 93.7 on the London and North-Western Railway, also 95.7 and 97.8 by engines of the "Atbara" and "City" classes on the Great Western Railway. On another occasion a Great Western locomotive attained a speed of 102 3 miles per hour for a quarter of a mile, and covered one mile at the rate of 96.8 miles per hour. Other records of 90 miles per hour for six miles and 80 miles per hour for 73 miles on end were also observed on the Great Western Railway. It will be seen, therefore, that, far from being not so fast as compounds, single-expansion locomotives are, indeed, much faster.

Birmingham, December 19th. CHAS. W. DAUNCEY.

ROLLING RINGS.

SIR,—It may help "Bothered" and his friends if they consider the case as that of a plunger which is surrounded by a number of discs threaded on to a wire ring. If the plunger is moving downwards the discs rotate. Consider the relative motion of points on the circumference of two neighbouring discs, it is obvious that there is no twisting between them, but only a reciprocating movement due to the difference in length between the circumferences of the plunger and its cylinder. As this is true for any two neighbouring discs, it is obvious that there is no twisting in the whole system.

Applying the analogy to the rolling ring packing, "Bothered" will see that all that is required of the ring is, that its material could stretch and contract between the lengths of circumferences of plunger or piston and cylinder. In fact, the rotation of the opposite sections of the ring is not really opposite, but—relatively to the ring—is looked at from opposite directions, as will be seen if the ring is considered to have been cut and straightened out

Bedford, December 21st. ARNOLD MAUDE.

SIR,—Your correspondent is "Bothered" because he has failed to observe that the imaginary discs which, put end to end, make up the rolling ring are revolving in the same direction if considered in relation to their common axis of rotation. The puzzle arises because the axis of the ring is a circle instead of being a straight line, as in a shaft. Let him cut the ring transversely, straighten it out quasi shaft, and roll it along a table in one direction. Looked at from one end, the direction of rotation will appear clockwise; and from the other end the reverse to clockwise, *i.e.*, in apparently opposite directions. In the diagram accompanying your correspondent's letter the ring is bent into a half-circle, and we are therefore looking at both ends of a revolving shaft simultaneously. G. P. FELL.

Heaton Norris, December 21st.

SIR,—The difficulty of your correspondent depends simply on the point of view. All the sections of the ring revolve the same way. Let him string some washers together and place them round a rod and move them like a rolling ring. Observe the direction of rotation of, say, the washers on the right-hand side of the rod, then twist the rod so as to bring every washer successively to the right of the rod. While at that point each washer will revolve the same way. The washers on the left side of the rod apparently turn the contrary way, but you are looking at their other sides. For the same reason carriage wheels when moving appear to revolve in different directions if one moves from one side of the vehicle to the other. Let "Bothered" turn his watch face downwards and contemplate which way the hands go round. Australians see the sun rise on the right and set on the left.

Rugby, December 21st. GEO. M. SEABROKE.

SIR,—It does not seem to require very much to bother "Bothered" and his friends.

The two opposite sections of the ring are not revolving in opposite directions, but in the same direction The top section is, however, viewed from the front and the lower section from the back.

If "Bothered" will put a thick rubber ring on a pencil and work it up and down he would be no longer "bothered."

London, December 18th. DUPLEX.

DEPRECIATION OF MACHINERY.

SIR,—In your issue of last week Mr. A. Williams Price objects to the "complications" in my method of deciding the amount for renewals, &c., of machinery, and also objects to my omission further to complicate the method by allowing for interest which will accrue from this fund.

I was quite aware of the point he raises, and can easily make the necessary allowance in my diagram, but preferred for simplicity to keep to the arrangement shown; the interest earned by this fund—whether it is used in the business as is usual, or invested as a renewal fund—would be placed to the credit of the profit and loss account yearly, and thus prevent any unfair distribution of the earnings between earlier and later shareholders.

This would also enable the actual amount earned to be used instead of an assumed amount.

I cannot claim, like the gentleman named in Mr. Price's first paragraph, to have been speaking in either poetry or prose for forty years upon this subject, but I do know that it has not had the attention it merits in many engineering works, and I am pleased to note the increased interest that has lately arisen on the subject, due probably to the use of high-speed steel and improved labour-saving machinery which has rendered necessary the reconsideration of old methods for dealing with depreciation and renewals. C. PENDLEBURY.

December 21st.

LONDON AND NORTH-WESTERN DIAMOND.

SIR,—Old prints of Grand Junction engines show a diamond painted upon both tenders and wagons. The Ramsbottom goods engines in 1858 had the diamond upon the buffer plank and up n the back of the tender tank. The diamond is still on the North-Western wagons. In reply to questions, all one can find is that it is their "trade mark," and that the diamond is 6in. high and 8in. wide. To what part of the railway system does the diamond refer? X.

December 21st.

TRONDHJEM TECHNICAL COLLEGE.—A new technical high school—Tekniske Hoiskole—is being built at Trondhjem and will probably be opened in 1910. We understand that a professor in mechanical engineering, who need not necessarily be a Norwegian if he has sufficient command of the language, is to be appointed next year, when he will assist in the laying out of the plans for the engineering laboratories, &c.

HORWICH RAILWAY MECHANICS' INSTITUTE ENGINEERING AND SCIENTIFIC CLUB.—The third meeting of the session was held in the Institute on Thursday, December 17th, 1908, at 8 p.m. A paper on "Modern Tool Steel," by Mr. G. N. Shawcross, M.I. Mech. E. (hon. secretary), was read and discussed, the discussion being taken part in by Messrs. Etchells, Freeberne, Montgomery, Wilde, Millington, Critchley, McLaughlin, Sheridan, Atherton, Woolstencroft, and the Chairman.

THE CONCRETE INSTITUTE.—The Concrete Institute held its second general meeting on the afternoon of December 17th at the Royal United Service Institution, Mr. Edwin O. Sachs in the chair, when a paper was presented by Mr. William Dunn on "The Examination of Designs for Reinforced Concrete Work." In introducing the lecturer, Mr. Sachs announced that the membership of the Institute had already reached 400, and went on to say that the subject of the discussion before the meeting was one that must be of the utmost importance to all concerned in building construction, having regard both to the impending amendments of the London Building Act, the procedure of the Local Government Board regarding loan periods, and the powers being taken out by municipalities for framing by-laws on the subject of reinforced concrete. It was essential that the examination of the designs should be carried out on standard lines. Mr. Dunn, in his paper, dwelt at length on the necessity of care being taken in the examination of designs and the systematising of the manner in which designs were prepared and laid before the public authorities. He also dwelt on questions relating to the supervision of buildings in course of construction. A discussion followed, which was opened by Professor Beresford-Pite.

SEVENTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—In May, 1909, the Seventh International Congress of Applied Chemistry will meet in London for the first time, under the patronage of his Majesty the King and his Royal Highness the Prince of Wales. An organising committee has been formed, composed of delegates of the following scientific and technical societies:—Royal Societies of London and Edinburgh, the Royal Dublin Society, Society of Chemical Industry, Chemical Society Institute of Chemistry, Society of Public Analysts, Royal Society of Arts, Iron and Steel Institute, Institution of Mining Engineers, Institution of Mining and Metallurgy, Society of Dyers and Colourists, International Association of Leather Chemists, Institute of Brewing, Royal Agricultural Society of England, The Lawes Agricultural Trust, Pharmaceutical Society, Royal Photographic Society, Faraday Society, English Ceramic Society, London Chamber of Commerce (Chemical Trade Section), Manchester Chamber of Commerce, (Chemical Section), representing all the most important industries. Accommodation for the meetings of the Congress has been secured in the buildings of the University of London, the Imperial Institute, and the Imperial College of Science and Technology at South Kensington.

SOCIETY OF ENGINEERS.—The fifty-fourth annual general meeting of the Society of Engineers was held on Monday, December 14th, 1908, at the offices of the Society, 17, Victoria-street, Westminster The chair was occupied by Mr. Joseph William Wilson, president. The following gentlemen were duly elected by ballot as the Council and officers for 1909, viz.:—As president, Mr. Edward John Silcock; as vice-presidents, Messrs. Diogo Andrew Symons, Alexander Graham Drury, Francis George Bloyd; as ordinary members of Council, Messrs. Tom Edward Bower, Robert Wellesley Anthony Brewer, Augustus William de Rohan Galbraith, Percy Griffith, John Kennedy, Norman Scorgie, Henry Chawner Hine Shenton, Walter Arthur Valon; as honorary secretary and treasurer, Mr. David Butler Butler; as honorary auditor, Mr. Samuel Wood, F.C.A. The chairman announced that the following premiums had been awarded by the Council for papers read during the past session, viz.:—The president's gold medal to Prof. R. H. Smith for his paper on "The Design, and the Waste and Wear of Wheel Teeth;" the Bessemer Premium of books to Mr. Herbert Chatley for his paper on "Mechanical Flight;" a Society's Premium of books to Mr. A. H. Allen for his paper on "The Engineering Pros and Cons of the Metric System;" a Society's Premium of books to Mr. H. Conradi for his paper on "The History of Mechanical Traction on Tramways and Roads;" and a Society's Premium of books to Mr. H. C. D Scott for his paper on "The Destruction of Arch Bridges."

BUSINESS ASPECTS OF EARLY ENGINEERING.

By H. W. Dickinson.

It may be interesting to those who are engaged on the commercial side of mechanical engineering—to which greater attention year by year has to be devoted—to glance back for a short time to the early days of the introduction of the steam engine and notice the change that has taken place since then in the ways of conducting business.

For our facts, and incidentally for many interesting points as to construction and operation, we shall rely mainly upon the very complete legal agreements which were entered into between the contracting parties; a few of these have fortunately been preserved. But for these, indeed, in the case of Newcomen's atmospheric engine many vital facts would be unknown. This is not so remarkable when we reflect that this capital invention arose in the brains of and was devoloped by blacksmiths and millwrights, who were accustomed to handle the hammer rather than the pen, and was unknown to or passed unnoticed by the learned and wealthy in the early years of its development.

The first deed with which we are acquainted is an agreement entered upon May 25th, 1725, betwixt John Meres and others, constituting "the Committee appointed and authorised by the proprietors of the Invention for raising Water by Fire of the one part, and Andrew Wauchope of Edmonstone, Esq., in the County of Midlothian," of the other part. The deed witnesses that the colliery of Edmonstone "cannot be wrought by reason of water," and the Committee license the erection of one engine, "according to the method and manner now used at the coal work of Elphinston, in Scotland," with a cylinder 9ft. long by 28in. diameter, in consideration of a yearly rent or royalty of £80 per annum during the unexpired term, *i.e.*, eight years, that their "grant and licence" has yet to run. Should the rent remain unpaid, distraint could be levied, but should "the coal work be wrought out," or the engine stop by reason of accident of any kind, "above the space of three months," a proportionate abatement of the rent was to be made. It is stipulated that the engine shall be used solely for the colliery of Edmonstone, and, to ensure this, the servants of the Committee aforesaid are to have access at all times to the premises for inspection. It is also agreed that, if the engine be not erected before December 25th of that year, the licence shall cease and be void, provided that the Committee furnish the necessary "cylinder, iron barrells, regulator, and other brasswork within the limits and space condescended on."

The attestations took place in Edinburgh and London, and it seems that the lawyer in the case took the deed in person up to town, as he appears on both occasions. There is an interval of a month between the attestations; the speed of travel and of business have accelerated mightily since then!

The engine was duly completed, and we have a receipt dated December 10th, 1735, for the sum of £240, accepted in "full and compleat satisfaction of the whole obligements contained in the foregoing articles and annuity," and signed by the proprietors or their executors. Probably the engine had not been at work during the whole time, and a deduction from the amount of £640 agreed upon was therefore made, as expressly stipulated.

Some interesting deductions may be made from the deed. The "grant and licence" of the Committee or, as we should say now-a-days, of the Syndicate, for the sole use of the said engine was for eight years subsequent to 1725, *i.e.*, till 1733. The only grant that will fit in with this date is that of a patent to Thomas Savery in 1698 for a term of 14 years, which in the following year was extended by Act of Parliament for 21 years beyond the original term, or 35 years in all. The engine under consideration being a Newcomen or atmospheric engine, it follows that that engine was exploited under Savery's patent, although the inventions were totally dissimilar, Savery's patent being for an apparatus like the modern pulsometer. This is not so remarkable as it seems at first glance, because Savery's was a master patent sufficiently wide to cover all means of raising water by "the impellent force of fire." Savery and Newcomen must, therefore, have joined forces, and subsequently have been bought out by this Syndicate of commercial men. An interesting point is that neither Savery's original patent nor its extension covered Scotland. Probably there were no means of obtaining an engine except through the Committee, and it was therefore practically a monopoly everywhere. This would appear to be confirmed by the fact that the first Newcomen engine on the Continent—that at Königsberg in Hungary—was erected by one Isaac Potter, without doubt another of the family of engineers mentioned below.

We have also detailed costs entitled "An account of Money paid for a Fier-Engine belonging to the Honourable the laird of Edminston, by John Potter, Engineer," elsewhere stated to be of "Chester in the Street" "in Bishoprick of Durham." From this account it appears that the engine was erected by Potter, presumably as agent for the Committee and not on his own behalf, and, further, that the materials came from all over the country.

The chief item is the brass cylinder, which cost the enormous sum of £250, or a quarter of the whole amount! This came from Coalbrookdale (as we learn from another source) by land to London, as did also the piston and other brass castings, whence they were forwarded by sea to Newcastle. Another important item is £103 for the "ironwork about the engin," excluding the "iron-hoops for the pumps," which cost another £33, and that of "plates and revet iron for making the boyler," which was £75 10s. 0d. The pumps themselves came from London, and cost £53. Another item is for the "plumbers bill for lead and a lead top for the boyler, sheet lead and lead pipes," which, with the carriage from Durham, amounted to £81. The timber for the engine came from Yorkshire and, with carriage, amounted to £87.

Apparently the erection occupied two men 20 weeks between July 12th and December 1st, 1726, as that is the time that is charged for at the rate of 15s. per week each.

The total cost, exclusive, of course, of the engine-house and boiler setting, amounted to £1007 11s. 4d., which, taking as our standard the remuneration of labour, we ought to multiply by four to obtain the cost at the present day.

Potter gave his receipt for the money on July 1st, 1725, to Andrew Wauchope, but apparently the cost was really defrayed by a certain James Smith, who had taken a lease of the colliery from Mr. Wauchope.

Smith entered into an agreement with John Potter and his "brother german"—*i.e.*, a brother through both parents—Abraham Potter, on February 16th, 1727. By this it appears that as soon as "the said engine, &c., is fully repaired and made a sufficient and well-going engine," Abraham Potter is to receive a salary of £200 per annum in return for working the engine—except supplying coals—and maintaining it in repair. Abraham was also to be steward and factor of the colliery for the whole term of the lease. After the expenses of "making pitts or drifts and hiring labour and the cost of the engine have been paid out of profits," the two Potters are to share equally one-half of the net profits! This is sufficiently indicative of how arduous and expensive an undertaking it was to enlist the power of the steam engine in the year of grace 1725.

We now pass over half a century, during which the atmospheric engine after yeoman service is beginning to be displaced by the more economical engine of James Watt, embodying the separate condenser.

It was not till the celebrated partnership between the latter and Matthew Boulton was entered into in 1775, after an extension of Watt's patent for twenty-five years from that date had been obtained by Act of Parliament that Watt's engine began to be exploited with the aid of Boulton's unrivalled commercial ability.

The indenture we now recite, dated December 30th, 1779, is between James Watt and Matthew Boulton, of the one part, and Joseph Beauchamp and co-adventurers in the United Mines of Gwennap, Cornwall, of the other part. The deed witnesses that the adventurers have applied to Boulton and Watt for permission to erect at their own expense two engines—one with a cylinder 58in. diameter by 9ft. stroke at Ale and Cakes Mine, and the other with a cylinder 48in. diameter by 8ft. stroke at Poldory Mine. The adventurers agree to erect the engines before the 30th August, 1780, and keep them in order during the residue of the term of Watt's patent, the plans and directions to be supplied by Boulton and Watt. The parties agree that "according to acknowledged matters of fact and calculations made thereupon a common fire or steam engine of equal power or force and of the same length of stroke" as the new engines proposed would show a coal consumption as in the tables annexed to the indenture. In order to give satisfaction to Boulton and Watt, and to ascertain the advantages that will arise from the use of the engine "by lessening the consumption of steam and fuel," the parties agree to appoint a person who shall each calendar month weigh the coal consumed and measure the quantity of water and the depth from which it is raised by the proposed engines. One-third part of the saving of fuel, as compared with the common engine at the net price of the coal delivered, is to be paid once a month to Boulton and Watt. If the coals are not up to the standard of the district, they may be rejected or an allowance may be made. Workmen, engine-men, and firemen are not to be employed unless approved by Boulton and Watt. The water raised for condensation shall not be deemed part of the load on the engine, but if any considerable length of flat or horizontal pump rods be introduced, an experiment is to be made of the power or friction absorbed, which shall be allowed to be part of the load. The engine at Ale and Cakes Mine when finished is to be able to work a pump of 15in. diameter by 80 fathoms deep at the rate of ten strokes of 6ft. long per minute. The engine at Poldory is to work a pump 15in. diameter by 50 fathoms deep at the rate of 10 strokes of 6ft. long per minute. If the engines cease working, the payments are to stop. Boulton and Watt reserve the right "to fix to or upon the said engines such machines or counters as they shall think proper and necessary to determine and keep account of the work done by the said engines respectively."

The tables appended to the deed give all quantities in words and explanations of each column at great length. Briefly expressed the tables are:—

Table I.

"Ale and Cakes" Engine.

Load on piston in lb. per sq. inch.	Weight in lb. of columns of water in pumps taken at the cylinder end of the beam.	Bushels of coal consumed in 30 days by a fire engine, 71in. dia., making six strokes 9ft. long per minute.
1	3,963	4,403
2	7,926	5,017
3	11,889	5,631
4	15,852	6,245
5	19,815	6,859
6	23,778	7,473
7	27,741	8,087

Table II.

"Poldory" Engine.

Load on piston in lb. per sq. inch.	Weight in lb. of columns of water in pumps taken at the cylinder end of the beam.	Bushels of coal consumed in 30 days by a fire engine, 58in. dia., making six strokes 8ft. long per minute.
1	2,714	2,681
2	5,428	3,054
3	8,143	3,428
4	10,857	3,802
5	13,571	4,176
6	16,286	4,549
7	19,000	4,923

The engines under review were amongst the earliest erected in Cornwall by Boulton and Watt. Having seen several engines erected and working successfully in the Midlands, the Cornishmen became anxious for them to enter their district, where the limit of depth in mining with the Newcomen engine had been almost reached. Boulton and Watt's first engines in the district were at Wheal Busy, near Chasewater and Tingtang, near Gwennap. These having proved to the incredulous—and they were numerous withal—their immense superiority to the Newcomen engines, a big demand for the new engines sprang up. Then came the question of payment. Watt having claimed in his patent the "lessening the consumption of steam and fuel in fire engines," it occurred to him naturally that a fair arrangement would be to take some proportion of the saving made by his engine as compared with the common engine. Experiments had therefore to be instituted to determine the amount of water raised per bushel of coal—the average weight of the bushel of Welsh coal is considered to be 94 lb.—by the engine which it was desired to replace. The nature of these trials—which may be said to have laid the foundation of systematic engine testing—is shown by the following memorandum* on two engines made at a neighbouring mine a year earlier.

"Poldice Mines, October 30th, 1778.

"We, the under subscribers, having carefully examined the books of the mine touching the consumption of coal of the two eastern engines during the months of August and September of this present year, and attended to the working of the engines during those months, do hereby certify that the said two eastern engines did consume in sixty-one days of those two months 220 weys of coal, each wey being sixty-four Winchester coal bushels, which amount to 14,080 bushels in sixty-one days.

"We do also certify that the said two engines together do work pumps in four lifts which are 17in. diameter in the working barrels, and the whole depth from whence these pumps drew water to the adit is 58 fathoms.

"We further certify that the said engines did, during those months of August and September last, work the said pumps at the rate of six strokes of 5½ft. long each in every minute, which amounts to 8640 strokes per twenty-four hours.

(Signed) "James Watt.
"Matthew Boulton.
"H. Hawkins Tremayne.
"Richard Williams.
"John Williams.
"Thomas Brown."

The name of H. H. Tremayne occurs in the deed under review as one of the co-adventurers, and that of Richard Williams occurs as a witness.

The figures in the tables attached to the deed are therein acknowledged to have been calculated—this is also shown by the constant difference between each succeeding row, in all three columns—and we may reasonably assume that the figures obtained at Poldice Mines were those adopted as the basis of this calculation.

The term "duty," *i.e.*, the number of pounds of water raised 1ft. high by the expenditure of 1 bushel of coal, had not then been adopted, but for Poldice engines it works out at 7,047,430, which may be taken as a fair performance for a Newcomen engine at this date. If we take the last row of figures in each table of the United Mines engines as being the common vacuum [*i.e.*, 7 lb.] at this period, we obtain duties in both cases of almost exactly 8,000,000, which help to strengthen the assumption materially.

The ratios of the cylinder volumes of the proposed Watt engines to those of the common fire-engines are as 1 : 1½, but on the other hand the piston speeds are as 1⅔ : 1, so that the combined ratio is 10 : 9. On this basis the engines were practically equal.

It is not a great step in advance of the method shown in the memorandum quoted to determine from the figures a load factor which, multiplied by the number of strokes made, would give the quantity of the water raised. Watt, therefore, schemed his engine counter—a weighted pendulum acting as a reversed escapement to a train of wheels—which was attached to the engine beam and put under lock and key. This was what was contemplated in the deed under review, and, indeed, is the earliest mention of this contrivance we have met with. The obvious defect was that the instrument counted the short strokes equally as well as the long ones. This, and the refinements of calculation possibly, were too much for the Cornishmen, and led to disputes and trouble. Watt was reluctantly persuaded by Boulton to give up his carefully compiled tables and accept a fixed annual royalty for each engine based on its dimensions and number of strokes.

The duty obtained by Watt about this time was 18 millions, but he obtained from the Poldice engine in 1792 a duty of 32 millions, although the general average, of course, was below this.

When Watt, in 1782, introduced his rotative engine, its power was calculated on the basis of the number of horses it could displace. There were no such means of determining experimentally, as in the case of pumping water, the actual work done by the engine, so that we find the royalty plan again adopted. This is witnessed by a deed dated March 1st, 1786, between Watt and Boulton of the one part, and Samuel Davey Liptrap and partners of the other part. This is for the erection of a double-acting rotative engine, with a cylinder 17in. diameter by 5ft. stroke, to be used for grinding malt, &c., in a distillery near Whitechapel-road. The engine was to be of a "power or force equal to that which ten horses acting together do commonly exert, or that the power of the said engine shall be equal to the raising 33,000 lb. weight 10ft. high in one minute." The "compensation and satisfaction for such agreement to the setting up, erecting, using, working, and exercising the said engine," is the sum of £63 per annum during the unexpired term (*i.e.*, 14 years) of Watt's patent.

This deed gives an early date at which Watt was using his estimate of a horse's power. This estimate was designedly made liberal, and was in excess of actual fact, so as to give good value to a customer. The measure has survived anomalies such as Watt never dreamt of, *e.g.*, "nominal" horse-power, and has retained the value he assigned it.

Later on, when Boulton and Watt were nearing the end of their partnership, this royalty is dropped and they accept a lump sum for their engines, practically as done now. We find this in an indenture made June 1st, 1799, between Watt and Boulton of the one part, and James Lees and his partners in Werneth Colliery, near Prestwich, in Lancashire, of the other part. The deed witnesses that the latter are desirous of erecting two engines with all Watt's improvements, the cylinders of which are to be 14¾in. diameter and 3ft. stroke, double-acting, to be employed in drawing coals and water from the said colliery. They agree to pay Watt and Boulton for the latter's "skill, care, attention, and assistance in and about the construction and erection of the said steam engines, and as a reward and compensation for the same, and also for the materials to be found and provided by them," as detailed in a schedule attached to the indenture, the sum of £710 three months after the date of the first delivery of materials. The engines when complete are to be able to work "with a power or force equal to that which six horses acting together do commonly exert, or that the power of each of the said engines shall be equal to the raising nineteen thousand eight hundred pounds weight ten feet high in one minute."

The schedule referred to is a printed one, and is interesting in that the items "One Sun Wheel and one Planet Wheel," with their "fastenings and Connecting link," are crossed out and the words "Crank and brasses" substituted at the end. Pickard's patent for the crank had expired in 1794, five years before, and there was no longer any necessity for the sun and planet wheel mechanism.

The deed first mentioned is printed in Bald's "General View of the Coal Trade of Scotland, 1812"; the second and last are in the Patent-office Library, and were printed in 1872 by Mr. R. B. Prosser; the third is in the South Kensington Museum.

* "Phil. Trans.," 1830, page 122.

RAILWAY MATTERS.

THE Board of Trade have recently confirmed the undermentioned order, made by the Light Railway Commissioners: — Mid-Lincolnshire Light Railway Order, 1908, authorising the construction of a light railway from Sleaford to Kirkstead, in the Parts of Kesteven and the Parts of Lindsey in the County of Lincoln.

IT is probable that the four tunnels of the Pennsylvania Railroad Company between Manhattan and Long Island will adopt a track system consisting of treated red oak blocks, set in the concrete lining, on 20in. centres. The blocks will be anchored to the concrete by expansion bolts; and the 100 lb. rails, 60ft. in length, will be laid on 7in. by 12in. plates, $\frac{5}{8}$ of an inch in thickness. The plates will be fastened to the blocks by two lag screws, and the rails will be held down by clips and screw spikes.

ACCORDING to the *Railway News*, the Washington-street tunnel at Boston, built by the City Transit Commission, was opened for traffic on November 30th. The tunnel, not including the open incline, is about 6100ft. long, and it is leased to the Boston Elevated Railway, providing for the trains of the elevated road, which, contrary to the original plan, have temporarily been using the Tremont-street subway, to the exclusion of certain surface lines (Tremont-street and Shawmut-avenue), which have now returned to the subway tracks, greatly augmenting the company's facilities for transportation.

AT the close of the summer part of this year's Parliamentary session all the railway Bills of the year had been disposed of with the exception of the Ards Railways Bill (originally called the Ards and Bangor Railways Bill). It passed through the House of Commons, but the Committee of the House of Lords to whom it was referred did not report it to the House till a few days ago. On Wednesday it was read a third time. The North British Railway Order Confirmation Bill, which was introduced at a comparatively late period of the session, was read a third time and passed in the House of Commons on Wednesday, December 16th.

THE sixth of a series of returns made under the Regulation of Railways Act 1889 of periods of duty in excess of twelve hours worked by certain classes of railway servants in the United Kingdom, and of instances of resumption of duty after such periods with less than nine hours rest, has been made to the Board of Trade. In the present case July is the month taken, and the return deals with 111,707 servants, who worked during that month a total of 2,826,167 days. The number of days on which the men were on duty for periods exceeding twelve hours by one hour and upwards amounted to 1.04 per cent. of the total days worked. Passenger guards, engine drivers and firemen, goods guards, brakesmen, and engine drivers, as well as signalmen and examiners, are all included in the return; and of these 26,256 are shown to have, on one or more occasions during the month, been on duty more than twelve hours at a time.

WE hear that the directors of the Metropolitan District Railway Company have decided to grant to the public the free use of their subway between South Kensington Station and the Albert Hall. Hitherto a toll of 1d. has been charged, but though the subway is a great convenience and time saver for those visiting the Albert Hall and the South Kensington Museum, the charge had the effect of deterring the public from using it to any great extent. A new stairway leading from Cromwell-road into the subway is being built, and, with the permission of the South Kensington authorities the stairway near the entrance to the Natural History Museum will be thrown open. One of the entrances is almost directly opposite the new museum, which will be opened by the King shortly. The subway will be available during all the traffic hours on the District Railway. The company hopes to be able soon to beat the record which it at present holds of running thirty-four trains an hour.

A recently issued report the Highways Committee of the London County Council states that, a question having been raised, and varying statements having been made, as to incidents which have occurred during the experimental working of the G.B. system in the Mile End-road, they have decided to make the following report to the Council of information given by the Council's officers as to the number of live studs, accidents, and claims incidental to the working of that system of electric traction on the Aldgate to Bow tramways:—There were 927 occasions recorded on which alarm indicators operated on cars, showing that studs remained alive immediately after the cars left the studs; 728 of these cleared themselves; 185 cleared after being hammered; seven studs would not clear, and remained alive. The total number of cases in which it had been reported that accidents occurred, or were alleged to have occurred, is seven. In three cases claims were received and dealt with by Mr. Godfray, the solicitor acting for the Council in connection with accidents on its northern system of tramways, and under the general authority given to him to settle claims during the summer recess up to £50, or between meetings of the Committee up to £25, Mr. Godfray settled these claims by payments amounting in all to £60 4s.

IN the Railway and Canal Commission the Commissioners, consisting of Mr. Justice A. T. Lawrence, Mr. A. E. Gathorne Hardy, and Sir James Woodhouse, recently gave judgment in the case in which the Board of Trade made a rule imposing the use of a uniform brake upon all railway companies. The brake recommended for general use by the Board of Trade was applicable from only one side of the wagon, although some years ago they recommended the use of a brake which might be applied or released from either side. The Great Western Railway Company, under the influence of the earlier suggestion of the Board, had devised and adopted, at a cost of £50,000 to £60,000, a brake applicable from either side, and now raised objection to the new rule of the Board of Trade that they should be compelled at great additional expense to fit their wagons with a brake applicable only on one side of the wagon. Mr. Justice A. T. Lawrence said in effect that during the last seven years the brake adopted by the Great Western had been proved to be a safe brake, and he would not compel them to adopt the Board of Trade brake. The other Commissioners concurred. The effect of the decision is that the Great Western Company can continue to use its own brake, and it was stated that so far as some other companies were concerned an arrangement would probably be arrived at.

AN interesting paper on "American Methods of Railway Accounting" was read on December 15th before the Royal Statistical Society by Mr. Samuel Chapman, formerly chief accountant of the Inter-oceanic Railway of Mexico, and honorary member of the Association of American Railway Accounting Officers. In his address Mr. Chapman recalls that a Committee representing about a dozen of the principal railways, after carefully considering the question of including in the companies' receipts a "schedule calling for the classification of ton-mileage and the classification of freight earnings according to some acceptable classification of commodities," came to the conclusion that "such separate earnings and ton-mileage by commodities, if compiled and furnished, would not form a reliable basis for any practical deductions or comparisons." In view of this, Mr. Chapman asks: "What practical deductions can be drawn or useful comparisons made from ton-mileage figures not even separated into commodities? Averages made up from a variety of results arrived at under conditions in many cases diametrically opposed cannot be other than misleading, and railway officials, for traffic purposes, require their information divided into sections corresponding with the different divisions of their lines rather than for the system as a whole."

NOTES AND MEMORANDA.

AT the Staveley Coal and Iron Company's Markham Colliery a huge lump of coal has been got. In the rough it weighed over 7 tons; after dressing it measured 3ft. by 5½ft. by 8ft., and weighed over 4 tons.

THE resistance of smooth surfaces to motion in the air when they are parallel to the direction of the motion, instead of perpendicular to it, has been investigated by Professor Albert Frank, of the Hanover Technical School. His report of the experiments, given in the *Zeitschrift* of the Society of German Engineers, indicates that about 236 square feet of side surface is necessary to develop the same resistance as results from 1 square foot of front surface placed perpendicular to the direction of motion.

A COUNTING machine that is reported to be an improvement over anything of the kind yet produced, the invention of a Swedish engineer, was recently supplied to the counting house of the Bank of England for experimental purposes, and its performance was highly successful in point of rapidity. The machine is operated by electricity, and is capable of counting up and sorting money into paper bags or tubes at the phenomenal rate of 72,000 coins an hour. The coins are placed in a receptacle at the back of the machine, and by mechanical means are sorted, stacked, and inserted into paper tubes.

THE following conclusions with regard to the rusting of iron, according to Mr. W. A. Tilden, are supported by experimental evidence: — Commercial iron, liquid water, and oxygen are together sufficient for the production of rust. Carbon dioxide is not necessary, but when present hastens the action. Commercial iron is attacked by pure water in the absence of oxygen and CO_2, the product being, not rust, but ferrous hydroxide. Iron rust always contains ferrous oxide. The process of rusting is due initially to electrolytic action resulting in the production of ferrous hydroxide or carbonate. This may be explained by the presence in all ordinary iron of various components which afford surfaces at different potentials in the presence of water, aqueous carbonic acid, or other electrolyte.

THE *Zeitschrift für Schwachstromtechnik* describes a system of electric clocks which is now being erected at Gotha, and which serves a number of public buildings and churches as well as thirty-five private houses. The master clock is fixed in the town hall, where it works an electric transmitter, and thus controls the system. This regulation has been designed to feed six lines, each of which has a capacity of six clocks. The pendulum of the master clock is electrically connected to the observatory, so that if it swings too quickly its motion is retarded by a magnet. The working battery consists of ten large cells connected to the system through a small switchboard on which are mounted instruments and lightning arrester apparatus. The subscription for one of these clocks is 25s. per annum, extra clocks being charged at half the usual rates.

AN electric barometer has recently been invented which depends for its operation upon the short-circuiting of a U-shaped carbon filament by means of a barometric mercury column. The filament dips into the top of the column, and as the atmospheric pressure increases, the mercury rises in the tube, cutting down the length of the exposed part of the filament, and thus reducing the resistance. As the mercury is also affected by temperature, a second filament and mercury column is provided. In this column the tube is sealed, so that the mercury will not be affected by atmospheric conditions. As the filament is more or less covered by the thermometric column the resistance correspondingly varies, and this variation in resistance is introduced in the circuit of the barometric filament so as to counteract the temperature variations in the latter.

IN a recent number of the *Comptes Rendus* is a report by M. Bouquet de la Guye on the determination of longitude by wireless telegraphy. After reviewing the importance to navigators of this question, and the various methods by which longitudes have hitherto been determined, the report discusses the possibility of sending signals, at pre-advertised hours, from the summit of the Eiffel Tower. It is concluded that such signals could be sent say, at midnight, when there would be least interference, and that ships in any part of the Atlantic, for example, could thereby receive the correct time necessary for the determination of longitude A recommendation that the necessary experimental apparatus be erected on the Eiffel Tower as soon as possible was obtained from the Bureau des Longitudes, endorsed by the committee, and forwarded to the Ministers of War and Marine.

A COMBINED carbon-filament and mercury-vapour lamp is being introduced in Germany. The filament is enclosed in a U-shaped tube, in which is a drop of mercury. The air in the tube is exhausted, and in its place an inert gas is introduced, to permit the conduction of heat from the filament to the mercury. The U-shaped tube is enclosed in a bulb similar to the ordinary incandescent electric lamp bulb. When the current is turned on, the carbon filament is immediately rendered incandescent, and the mercury gradually vaporises, increasing the light intensity to more than double the value of that of the filament. A maximum intensity is obtained in about five minutes. The lamp consumes from 1.5 to 1.6 watts per candle-power, and its life is from 600 to 1000 hours. The light it yields is perfectly white, containing none of the blue-green rays of the ordinary mercury-vapour lamp.

A LARGE part of the November number of the *Physikalische Zeitschrift* is devoted to the papers read at the Versammlung deutscher Naturforscher und Aerzte at Cologne in September. Amongst a number of interesting communications, we note one from Dr. J. Classen, of Hamburg, on the value of the quotient electric charge by mass for the kathode rays. His method is that of Kaufmann, in which the velocity of the electron is taken to be that due to its passage through the electric field between kathode and anode, and the effect of a magnetic field on the path of the electron is measured. In Dr. Classen's experiments a Wehnelt kathode is situated a millimetre in front of a large anode with a hole a millimetre diameter at its centre, and the discharge tube is placed in a magnetic field due to two large coils arranged in the Helmholtz manner. The deflections of the rays are determined photographically. The value of the quotient obtained is 1.77×10^7, *i.e.*, considerably less than the 1.86×10^7 obtained by Kaufmann.

IN a paper read before the Australasian Inst. of Mining Engineers, the author criticises the Reuleaux and Hrabak formulæ for the stresses due to bending in a wire rope. From the change of curvature of a single helix whose axis is bent into a circle it is readily deduced that the maximum stress due to bending is $(E d \cos^2 \alpha \cos^2 \beta)/D$, where E is Young's modulus for the steel of which the wires are made, d is the diameter of each wire, D that of the rope, α the angular pitch of the wires in the strand, β that of the strands in the rope. In direct tension each helix of wire is not perfectly free to behave as a spiral spring in tension; hence, although the elongation of the rope as a whole is greater than it would be if it consisted of a bundle of parallel wires, yet it is not so great as for a number of free helices. Doubtless to some degree the same action occurs in a rope bent over a pulley. Tables give the tensions required to produce the same stress as given by the bending for various ropes and diameters of drum. The results of experiments are given in which pieces of rope were bent by a known force or to a known radius. The formula is found to be in good agreement with the results. By bending in the opposite direction the work absorbed in overcoming internal friction is estimated. This amounts approximately to $M l/2R$, where M is the bending moment required to bend a length l of the rope to radius R.

MISCELLANEA.

REGULATIONS relating to wireless telegraphy in the British East Africa Protectorate have been issued recently; these provide that no person may establish any wireless station, or erect any apparatus for wireless telegraphy in any place, except under licence granted by the Governor.

WE hear that the Westminster City Council recently decided to permit Mr. E. L. Walford to experiment with Sir Oliver Lodge's system of dissipating fog by means of electricity. The experiment will be made on a portion of the Grosvenor Canal property, provided that it can be carried out without detriment to the Council's work and without danger.

THE Carnegie Institution is at present building a vessel which is to be used for the purpose of conducting experiments in, and a general study of, magnetic conditions in all parts of the world. The vessel is remarkable in that every portion of it is to be absolutely non-magnetic. Even the anchors are made of bronze. A large sum of money is being spent upon the ship, but the most valuable results are expected.

ACCORDING to a contemporary, Signor Marconi is said to have stated that a wireless telegraphic service at a penny per word will shortly be in operation between England and Italy. France, it is said, objected to the scheme originally, as telegrams between England and Italy pass over her lines at present, but has since withdrawn her opposition. It is stated that the service will be commenced as soon as the wireless station at Coltano is completed.

THE Home Secretary informed Captain Faber in the House of Commons on December 17th that under Section 6 of the Petroleum Act, 1871, all petroleum spirit sold or exposed for sale must be marked "Highly inflammable," under a penalty of not more than £5 and forfeiture of the spirit. He added that he is about to appoint a Departmental Committee to inquire into the sufficiency of the existing regulations relating to the storage, use and conveyance of petroleum spirit, and to report what further precautions are desirable.

THE debate on the Naval Estimates was concluded in the French Senate on December 17th. In reply to a remark that Great Britain not only built her ships more quickly than France, but did so, on an average, 35 per cent. more cheaply in the case of battleships, and 50 per cent. more cheaply in the case of cruisers, M. Pichard, Minister of Marine, pointed out that France would always have to pay for her ships more dearly than Great Britain. France, he said, had neither the iron nor coal possessed by Great Britain, nor could any adequate idea be formed of the yearly orders placed by the latter Power.

THE necessity of increasing the number of docks continues to be felt at Hamburg no less than at other ports abroad, in spite of the already extensive accommodation for shipping existing there. Since the last considerable extension took place, viz., in 1897-8—though two new docks have been opened since then—the aggregate tonnage of sea-going vessels visiting this port has increased from about 7,500,000 to 12,040,000 register tons in 1907. In consequence of this remarkable development, and although two new docks were opened in 1903, the want of sufficient room for quay berths has been acutely felt.

THE *Deutscher Reichsanzeiger* — Berlin — of 30th November contains a notice to the effect that the District Authorities of Vilna, acting on the representation of the Timber Industry Society of the North-Western Province, have petitioned the Department of Ways and Means to consider the question of the construction of a harbour at Georgenburg so that rafts and steamers may be kept there over the winter. An engineer has been instructed to draw up the necessary plans, which will be submitted to a special committee formed in Vilna to deal with the matter. The cost of the work will, it is estimated, amount to not more than 250,000 roubles (nearly £26,400).

A REPORT from Johannesburg, dated December 17th, states that Mr. Lionel Phillips, speaking at a Chamber of Mines meeting on that day, defended mining amalgamation. He said it was a fallacy to suppose that lower working costs meant less circulation of money. He instanced the Modderfontein amalgamation, where one mine working alone would have expenses exceeding the gold recovered, whereas the amalgamation had resulted in the supply of plenty of capital for development, thereby increasing the general output. Mines with low grade ores, said Mr. Phillips, had become payable through the reduction of working costs following upon amalgamation over large areas, thus giving greater security to the investor.

ACCORDING to a contemporary, President Roosevelt has recently appointed a commission for the revision of laws relating to the safety of life at sea. One of the most important duties of this commission lies in a careful revision of the laws which relate to the construction and inspection of steam boilers. The rules at present in force are very much out of date, and need thorough revision to meet the requirements covering the best materials and best methods of modern practice in construction; expert inspection in materials, design, and workmanship; conformation of the United States rules with the requirements of marine insurance companies; and adequate provision for conditions on the Great Lakes and Mississippi River with its tributaries.

SPEAKING at the Society of Arts in London on the subject of explosives, Mr. Oscar Guttmann said it was still the practice in men-of-war to arrange the ammunition stores and powder magazines in close proximity to boilers and engines, frequently without any ventilation, while at times explosives of all kinds were stored together. Fourteen years ago he drew attention to the dangers arising therefrom, but a dozen explosions in men-of-war and a disaster like that in the Jena occurred before an alarm was raised. Now all navies were hurriedly providing refrigerating apparatus. That was all very well as far as it went if the machinery did not break down at a critical moment, but why could not designers of warships find another place for ammunition? Why go to the length of all sorts of precautions, when it should not be impossible to move the cause of deterioration altogether?

THE United States navy, states an American contemporary, is pointing the way to an important reform in the treatment of railway workmen laid off because of business depression. These men in the old days usually were allowed to go and be lost in the general drift of workmen. Not so in American navy yards, however. Realising the value of good workmen in times of urgency, efforts were made to ensure their return as soon as conditions, chiefly appropriations, warranted. In the New York yard in Brooklyn, for example, the men laid off were registered at the Labour Board of the yard according to their rating as workmen whether "excellent," "good," or "poor." When men had to be engaged again by the Government these men had the call in preference to outsiders who know nothing of navy yard work. They were taken on in accordance with their standing on the books of the board. This principle is now applied by the Pennsylvania Railway when it has to lay off men. Instead of discharging them outright, they are "relieved" and kept on the company's books, and are re-employed on the seniority plan. In the navy yards merit in workmanship and conduct figure in re-employment. The wording of the paragraph of the order of the Navy Department dealing with re-employment is as follows:—"Workmen discharged with a rating as 'excellent' for workmanship and not less than 'good' for conduct shall be placed on reinstatement lists in the order of priority of original employment."

RECONSTRUCTION OF A PORTION OF THE CANADIAN PACIFIC RAILWAY

(For description see page 685)

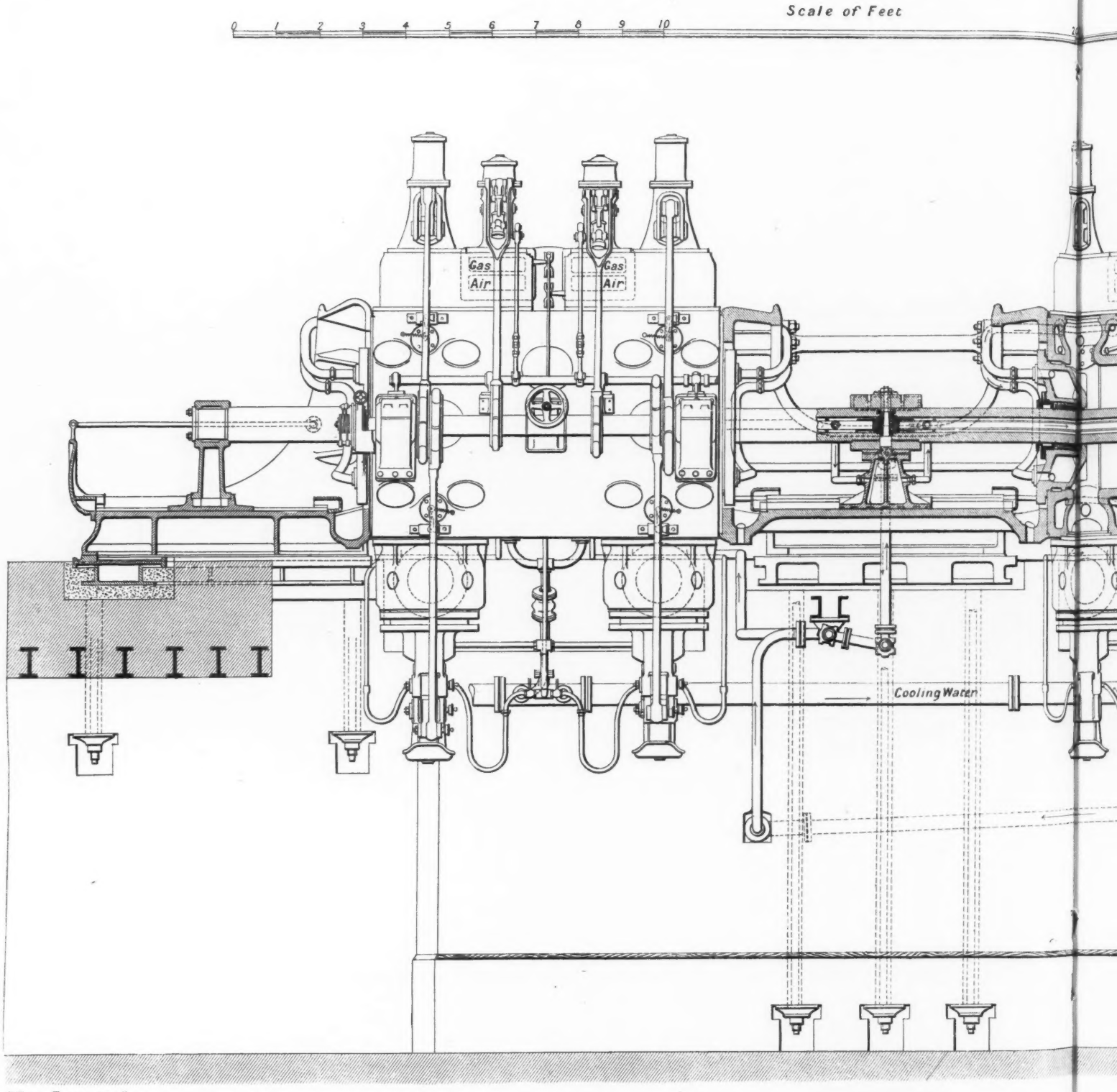
Fig. 3—A GRADIENT OF 1 IN 25

Fig. 4—THE POINT WHERE THE GRADIENTS ARE BEING IMPROVED

Fig. 5—VIEW OF THE CANADIAN PACIFIC RAILWAY IN THE KICKING HORSE VALLEY, BRITISH COLUMBIA

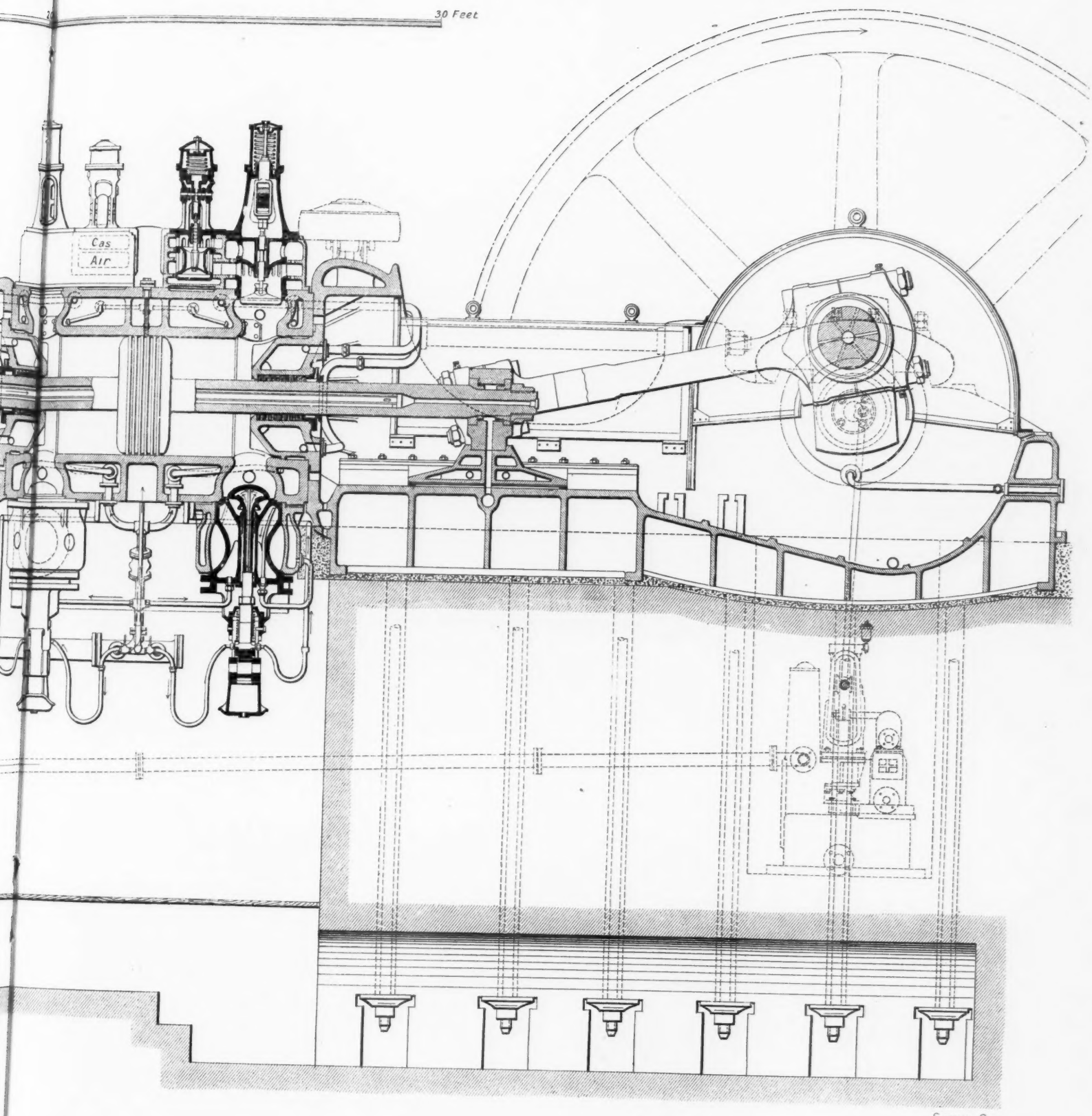
1200 HORSE-POWER TAN

MASCHINENFABRIK AUGSBURG-NU



ER TANDEM GAS ENGINE

RIK AUGSBURG-NURNBERG, ENGINEERS



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INQUIRIES.

DUST PREVENTER FOR ROCK DRILLS.

SIR,—Can any of your readers tell me if there has ever been a reward offered for an efficient dust preventer for rock drills? T. E. B.
December 18th.

THE ENGINEER.

DECEMBER 25, 1908.

The Training of Engineers.

THOSE of our readers who are interested in the future of engineering practice in this country are more or less familiar with the various methods of training recommended for young engineers and artisans, and probably remember that the North-East Coast Institution of Engineers and Shipbuilders has given this subject much consideration. Several years ago this Institution issued a report containing certain recommendations which have since been adopted with marked success by several large engineering works. As a result of the experience gained in the actual working of this scheme the Institution has now issued an amended and much improved edition of its earlier recommendations. A copy of this amended scheme will be found on page 679, and its contents are well worthy of careful study. Before proceeding to consider the Institution's recommendations, it may perhaps be well to glance first at what have been the customary methods of training adopted in this country.

Leaving out of consideration several works which in the last ten years or so have adopted special systems of their own, the method generally followed has been what is broadly termed "apprenticeship," although in many cases the apprentices are not now bound by any form of indenture or written agreement. Some of the larger works accept a certain number of young men, who, by paying an agreed sum of money, obtain certain privileges and are termed "premium apprentices" or "articled pupils." A good deal might be said in favour of the latter arrangement if the works in question made a point of carefully selecting their pupils and gave serious attention to their training, but outside a few notable exceptions this is rarely done, and generally the owners or directors of the firm have simply charged the premium, and in return have turned the young men loose in the works, allowing them to spend certain portions of their time in the various departments, and finally enter the drawing-office. The result has usually been that the managers and foremen who find their own time fully occupied with running the works, and receive no portion of the fee paid by the youths or their parents, take very little interest in them beyond perhaps somewhat relaxing the usual discipline for apprentices. Hence the youths drift through their time, those of strong character picking up a good deal on the way, and the weaker little or none. No wonder then that the premium system has fallen into disrepute in mechanical engineering. The cause of its failure, however, must, we think, be chiefly attributed to the lack of personal interest taken in the pupils by those receiving the premiums, and not to any inherent fault in the system itself, which is simply payment for superior training. The ordinary apprentices, viz., those who do not pay premiums, serve a term generally of about five years, which period is spent wholly in the machine and fitting shops, and in the erection of machinery; the conditions of their indentures, when there are any, usually stating they are to be trained as fitters, turners, and erectors—in other words, as mechanics or artisans. These apprentices gain no insight into pattern-making, moulding, or boiler-making. Young men required for the drawing-office are chosen from these apprentices in various ways. In some few works an examination is held, in many others the selection is made on no clearly defined basis, and is often simply a matter of influence or mere favouritism. From all of which facts it will be seen that the apprentice, whether he pay a premium or not, receives simply a training in one or more handicrafts, and whether he adds to this or not a study of the first principles underlying the manufactures in which he is engaged is left entirely to himself, and must in any case be acquired in his evenings or other spare time.

That both the above methods have produced and are producing many first-rate engineers and mechanics is undeniable, but that the system is capable of improvement is equally without doubt. Much that is useful and otherwise has been written on the training of engineers, and we are all familiar with the confusion of ideas which exists. This confusion largely arises from the comprehensive nature of the word "Engineer," which may mean anyone from a man engaged in highly scientific and novel design to a man superintending ordinary mechanical manufactures, or even a working machine. Now it is evident that the best form of training cannot be alike for the three examples cited above. Not only the training of the men, but their very natures should be different. The first should be an ingenious man of the highest mental activity, and possessing a thorough knowledge of the scientific principles involved in design, and with sufficient practical training thoroughly to grasp the limitations and best arrangements for commercial manufacture and mechanical working. The second may be less mentally alert, and have less scientific knowledge, but he cannot have too much tact and commonsense, and he must be thoroughly at home in mechanical detail and the most approved methods for the commercially successful production of machinery. He may know less of matter than in the first case, but he must know more of men. In the third case, the man attending a machine tool, no special education or scientific knowledge is necessary beyond ability to read an ordinary working drawing, but he must be a thoroughly trained handicraftsman who has spent years in acquiring special dexterity with his hands, and in gaining a certain limited mental mechanical acuteness and common sense which can only be acquired after years of work in the shops.

In the report of the N.E.C. Institution this difficulty is recognised, and a system of natural selection is recommended. It is proposed that certain youths who have shown special natural aptitude should be selected and given a more scientific training, and that instead of having to pay for this privilege, as in the premium system, the owners or directors of works should pay these youths on a higher scale than the ordinary apprentices, in recognition of their higher abilities and prospective greater future usefulness. This view may not find favour with some, but we venture to think it is sound in principle, and we hope to see its extension. One cannot expect to reap without sowing. The methods of selection recommended are divided into three sections—A, B, and C—the details of which will be found on referring to the scheme. If this method of careful first selection is intelligently followed, it will save much after disappointment for both pupils and employers. Nothing has more prejudiced the higher education and more scientific training of engineers in this country than the pernicious idea that engineering knowledge and experience could be stuffed into young men by educational short cuts, and the forgetting of the practical fact that engineering training, both in works and at college, can only be satisfactory when applied to young men having the necessary genius or mechanical instinct or temperament. Musicians do not recommend that youths without an ear for music should either practise the piano or study at the Royal College of Music; and if natural unfitness for engineering had been as easily detected as unfitness for music, many young men and their parents would have been saved much disappointment. Whatever method of training is adopted, only a certain percentage will ultimately be found to possess the peculiar combination of character and other qualities necessary to the making of a first-rate engineer; but careful first selection will certainly increase this percentage, and in this fact lies one great merit of the N.E.C. Institution recommendations. It must always be borne in mind that inherent genius will almost always assert itself, even under the most unfavourable conditions, and is independent of any system of training, but the real genius is a *rara avis*, who only appears occasionally, and gives the necessary lead in new directions, while the ordinary work of the world has to be carried on in the meantime by those less favoured by nature, and it is to secure the best from the latter species that systematic training is required. It is a remarkable fact that whilst this country has for many years given much attention

to, and spent large sums of money on, providing educational facilities for the evening study of elementary science, it is only in more recent years that serious attention has been given to the provision of facilities for the few who carry these studies beyond the elementary stages, and specially fit themselves for the higher posts where this knowledge is advantageous. This is all the more curious if it is admitted, and we think it should be, that the working mechanics of this country have been and are behind those of no other in handicraft skill, and that to make a first-rate working mechanic no scientific book knowledge is necessary. We think no one who has had the actual handling of men will dispute the latter. This fact seems to have been clearly grasped by those who framed the N.E.C. Institution recommendations, and the specialised higher training of a few selected youths in each works seems a move in the right direction. The report, however, does not stop at the special training for the higher posts of the few specially gifted, but in a section on "Regulations for Apprentices" outlines a scheme for the encouragement of such as will, in the nature of things, never be other than working mechanics, and for the systematic recording of their progress year by year. It will be noted in this connection that great importance is placed on good timekeeping. Marks on a reduced scale are given for quarterly reports of industry and conduct awarded by the foreman, and additional marks added for any satisfactory evening class work accomplished. If the marks gained by the boys are annually plotted in a curve any falling off is noted at once. Without such graphic records it is quite impossible for any foreman or manager clearly to grasp what regularity is being shown by the apprentices, and the results sometimes surprise both the youth and the management. The head boy in each shop each year will also, subject to the discretion of the firm, be allowed to choose a shift into any other department. This to a boy anxious to rise above the general level must prove a great boon. To encourage the youths bonuses will be given to all who secure above a certain number of marks, and at the termination of apprenticeship a concise and complete record of his yearly results will be handed to each apprentice. This is a great improvement on the loose and unsatisfactory system of "lines" or testimonials usually adopted. Another point in this amended report, and one which is in every way to be commended, is the arrangement for enlisting the interest of the parents by sending to them an annual report giving a list of all the apprentices placed in order of merit and indicating the number of hours lost and marks gained for industry in works and evening study by each apprentice. Any one who has had the management of apprentices, and the occasional pleasure or otherwise of interviewing their parents, knows only too well how woefully ignorant the latter frequently are as to how their sons are progressing, and much good must result from keeping them informed.

The Committee which drew up the original N.E.C. Institution report, and the Committee which amended it, were both composed of experienced practical engineers, men who have gone through a thoroughly practical training and are responsible for the management of large engineering works; and when it is remembered that the scheme was brought forward by a president of the wide experience of Mr. John Tweedy, and has been amended under the presidency of such a thoroughly practical engineer as Mr. Summers Hunter, and that the works which have adopted it have found it easily worked and to have a marked effect on the time keeping and industry of the apprentices, we have a guarantee for its suitability for the ends in view, and we commend it very heartily to the consideration of all interested.

The Limitation of Shipbuilding.

THE depression prevailing in the shipbuilding industry does not render the present an appropriate time for bringing forward suggestions in favour of a restriction in the amount of tonnage turned out at the various yards throughout the country. No doubt the new construction of merchant vessels completed in recent years has led to the supply being in excess of the demand when all classes are taken into consideration under existing circumstances. But it is reasonable to assume that this situation of affairs would not be manifested now if the trade of the world had not experienced an enormous diminution in the course of the past twelve months. Each of the principal countries interested in the promotion of commerce in international markets has felt the serious effects of the retrogression in the economic position, the United Kingdom alone having suffered a decline of £112,000,000 in the value of the imports and exports in the first eleven months of the current year, although it must not be forgotten that the amount involved compares with a period in 1907 of unprecedented prosperity in the trade of this country. A shrinkage of the magnitude in question naturally implies that numerous vessels which had plenty of cargoes a year ago must now be lying idle in different ports, and it therefore follows that shipowners are either unwilling or unable to enter into contracts for the construction of new vessels. Sir Thomas Sutherland, the chairman of the Peninsular and Oriental Steam Navigation Company, recently stated that no fewer than 3,000,000 tons of steamers have been added to the British register in a comparatively short space of time, whilst other nations have also been active in increasing their respective mercantile fleets. As the British shipyards annually produce a considerably larger tonnage than any other country in the world, it is apparent that they must experience a heavy reduction in orders when trade becomes slack and the requirements of shipowners in the matter of new construction are curtailed. This represents the position at the present time, although shipbuilders in other countries are also adversely affected by the influences of the economic depression.

The unfavourable condition of the shipbuilding industry having been brought about by the operation of the economic law of supply and demand, it is easily comprehensible that we must also look to the same law to effect an improvement, except, perhaps, under the abnormal events which would probably arise in the contingency of war. In the circumstances it must require considerable courage to suggest that a limitation should be placed upon the construction of new vessels in various countries. The proposal, which emanates from Mr. J. Kothe, who was formerly general director of the German Levant Steamship Company, represents an alternative scheme to that suggested by Mr. Ballin, general director of the Hamburg-American Steamship Company. As we pointed out in our issue of October 9th, the project put forward by the latter was for the British, United States, German, and French shipping companies engaged in the Transatlantic traffic to enter into an agreement as to the future course of their shipbuilding programmes, and it was also proposed that the companies should contribute to a joint fund for the purchase and breaking up of the old steamers used in this particular traffic. On the other hand, Mr. Kothe considers that it would be greatly to the interest of British and German shipping companies to arrive at an understanding with the shipbuilders in the two countries respectively, especially the builders of the so-called tramp steamers, whereby the shipyards would agree only to accept orders for new construction required in substitution for lost tonnage. The proposal, it is submitted, should remain in operation for one or two years, or for three years in case of necessity. As shipbuilders could not be expected to consent to such an arrangement without receiving compensation, it is suggested that they should be indemnified by the shipping companies either in the form of the allocation of repair works or by the guarantee of the dividends of the shipyards. The scheme would leave the Transatlantic shipping companies free to extend their building programmes, although their co-operation is deemed desirable to ensure complete success.

It is highly probable that the alternative scheme will be no more likely to commend itself to British shipbuilders and shipowners than the project recently advanced by the general director of the Hamburg-American Steamship Company. National and other considerations, as we recently intimated, are opposed to any British adhesion to an international plan for regulating the programme of construction in regard to swift Atlantic liners, and the same objections would arise in respect of other classes of merchant steamers. It is certainly strange that suggestions of this character should be made solely on behalf of German shipowners, and at a time when more orders, not fewer contracts, are needed by the British shipyards. Although our shipowners suffer very largely from the superabundance of shipping at the present time, we do not hear of any of them advocating a limitation of the output of new construction at any of the shipyards. The demand itself regulates the supply at any time, excepting in the case of speculative building, which assists in providing a certain amount of employment and affords an advantageous opportunity to shipowners to substitute new vessels for the older types. The extent to which the latter practice is pursued is shown by a recent statement to the effect that whilst British shipowners only possess 1,750,000 tons of steamers built over twenty years ago, the corresponding tonnage sailing under the flags of other nations amounts to 3,350,000 tons. It would, therefore, be disastrous to the British shipyards if shipowners refrained from modernising their fleets in this manner, and it would be equally unfortunate for them to take into serious consideration any proposal for further limiting the already restricted output of new steamers. The suggestion would, in fact, not be seriously entertained, as it would be impossible for all of those concerned to arrive at an agreement on the subject, whilst the shipowners would very probably hold aloof from any such scheme. Even in the event of certain shipbuilders consenting to curtail the production on agreed terms of compensation, others would refuse to do so, and would consequently stand to benefit from any attempt made to carry the project into effect. It is, however, questionable whether works of repair, which always have to be executed when necessary, or the guarantee of dividends, would afford such compensation as would justify any restriction in the output of private shipyards, especially owing to the losses which would result from the depreciation of machinery and plant lying idle for from one to three years; and everything in the circumstances points to the desirability of the British shipyards remaining free from any agreements of an international character.

Coal Prices in London.

THE prices of steam and other coal in the metropolitan area, as manufacturers and other consumers are only too well able to testify, are always higher than in other important markets throughout the country, and the question consequently arises as to whether there is any prospect of the disproportion being reduced in the future. The problem has been brought forward by suggestions made for increasing the tonnage of coal conveyed to London by improving the system of canals. If a comparison is drawn between the average price at the pit mouth in England, Wales, or Scotland, and the average prices in the London market, it is found how much per ton is absorbed by the cost of transport, sidings rent, merchants' profits, and cartage when necessary. These several charges for rail-borne coal have the effect of converting the London market price into more than twice the amount of the pit mouth value, but the average value of the fuel exported at the principal shipping ports is considerably less per ton than the coal reaching the metropolis. The price at the pit mouth in Wales is higher than in England and Scotland, the explanation probably lying in the special class of smokeless coal largely raised in the Principality. Although prices have declined in recent months, the Home-office Report on Mines and Quarries shows that the average price in the London market in 1907 was 19s. 9d. per ton, which, with the exception of the year 1900, when the mean reached 22s. 9d., was the highest in the past twenty years. In considering the question of coal consumption, it has to be remembered that the area of London is taken to be that of the Metropolitan Police district, which extends over 15 miles from Charing Cross, and comprises a population of over 7,000,000 persons. How important this area is to the coal-owning and merchant interests may be illustrated by the statement that its coal consumption represents 6 per cent. of the total production of coal in Great Britain, or 8 per cent. of the tonnage consumed in this country. In other words, the amount of coal brought to London every year is approximately 16,000,000 tons, or 4,000,000 tons in excess of the total quantity of coal annually used for locomotive purposes on the railways in the United Kingdom.

The quantity of coal brought to the metropolitan district increases slightly year by year, and the method of transportation is of particular interest because it bears upon a question recently placed before the Royal Commission on Canals by representatives of colliery interests with regard to the improvement of inland waterways. Thus in 1906 the tonnage of coal conveyed to London by rail amounted to 7,574,000 tons, that forwarded coastwise by sea reached 8,373,000 tons, and that sent by canal was only 25,000 tons, whilst the quantity transported by the three methods in 1907 was presumably in excess of 16,000,000 tons. It will be seen that the coastwise shipments were considerably more extensive than the deliveries by rail, mainly representing coal for gasworks, certain electric lighting stations, and manufacturing establishments in general on the banks of the Thames. The preponderance of sea-borne coal has obtained since

1902, according to the Board of Trade Coal Tables, and it is probable that the same condition of affairs prevailed in earlier years, if not to a far greater extent than at the present time. On the other hand, the tonnage of coal carried by canal to the metropolis is insignificant, although a slight increase has been noticeable in recent years. If, however, it were possible to improve the system of canal communication between the Midlands and London, particularly from South Staffordshire and Warwickshire, so as to enable the use of boat trains, the coalowners in these districts believe that a large trade would be created with London, provided that the cost of transport was thereby reduced by from 2s. 6d. to 3s. per ton for destination to Brentford and Paddington. These amounts are put forward as those which would represent economies over the present railway rates to the same places, and a similar saving is claimed to be possible in competition with the railway at other points. Such calculations are, however, mere assumptions which cannot have any weight in the matter in the total absence of any information as to what the canal rates on an improved navigation would actually be; and they also leave out of consideration the important circumstance that keener canal competition would result in more severe railway rivalry, and the railway rates might be reduced to the level of the canal rates in the event of the latter being lower, and thus nullify the effect of an improved system of canals.

Any endeavours made to reduce the cost of the transport of coal from centres of production to the metropolitan area would be welcomed by the owners of engineering and industrial establishments and by consumers in general, provided that they were confident of being able to participate in the estimated economy resulting from lower freight rates, if introduced, on improved canals. But if cheaper rates are assumed to be possible, and they were brought into application, would London consumers stand to derive any financial advantage from the fact? The answer is practically embodied in the observation made on behalf of one colliery, that if the company could secure the London market it might undersell to a certain extent those who control the trade at the present time. The statement and the accompanying qualification are certainly of interest, because they show in this case, and probably with regard to other coalowners, that with lower rates on a more satisfactory system of canals new competitors might dispose of coal in the London area at cheaper prices than the existing coalowners and merchants concerned; whilst, on the other hand, they might adhere to the ordinary market quotations. It is quite likely that new rivals might undersell at the beginning in order to gain an entrance to the market, but we believe they would soon raise prices to the normal level, and the position of consumers would not be improved in any way whatever. If, however, lower prices were charged for canal-borne coal for a time the colliery owners and merchants who regulate the London coal trade in rail-borne coal would in all probability soon find means of counter acting the competition of new rivals and of compelling them either to work in harmony or be squeezed out of the market. The prospect of cheaper coal for London than that provided by existing interests is in the circumstances largely a delusion, and even the remote idea of obtaining coal from Kent does not improve the outlook from the standpoint of consumers throughout the metropolitan area.

The Generation of Steam.

IN this country for some time past boiler engineering has settled into a groove. There have been times of storm and stress—storm and stress so violent, indeed, that it might have been thought that the very existence of the British Navy, to say nothing of mills, factories, and electric light stations, hung in the balance; but sanity has returned to our counsels, and a few types of steam generator have established their claims to general adoption. The interest has shifted from the boilers to the furnaces—from the tool, so to speak, to the nature, method, and kind of work done by that tool. The two factors of interest are the combustion of coal and the purification of feed-water. The unfortunate fact as regards the first is that the conditions of making steam and burning coal to perfection are in the main incompatible. At best they only admit of partial reconciliation. An army of inventors have been struggling after that reconciliation from the very beginning. It is questionable if much progress was made until recently. The purification of water is a simpler matter, and yet as it cannot be effected without outlay it has not become as popular as it ought to be.

In the United States for some time back enquiries, exhaustive as far as they went, but limited in their range, have been in progress to settle, if possible, the best conditions under which coal can be burned. We have from time to time dealt with these inquiries, which have been carried out by a committee of the United States Geological Survey. The general results can be easily stated here. Almost any kind of coal can be burned in a way to get the most power out of it without smoke, by using a chain grate, a continuous feed, a long brick arch, and proper means of regulating the admission of air. In all this there is nothing complex, expensive, or demanding extra skill on the part of the fireman. We have in effect a development of the old Jukes travelling grate. It is unfortunately difficult to secure the requisite furnace capacity with any but water-tube boilers; and there is very little "elasticity" about the firing—that is to say, the velocity of the grate, the thickness of the bed of fuel on it, and the amount of the draught being once fixed, any change may do harm. The system does not apply well to boilers which are at one period worked very easily, and at another are driven as hard as they can go. Unfortunately this is just a condition that must be provided for in many cases; it is normal in most generating stations.

The burning of coal is a very simple matter, and presents no difficulty. The burning of the gas which is produced during the combustion of the coal is the source of trouble. The products of combustion consist of gases distilled from the coal, with nitrogen, and now and then a little free oxygen. There is also usually a great deal of steam, at all events at the top of the chimney, tending to augment the apparent volume of the smoke. The burning of a gas consists in its combination with oxygen at a high temperature. If, on the one hand, the temperature is too high, this combination will not take place. According to some recent authorities the perfect combination of carbon with oxygen is impossible unless water vapour is present. Failing this we have C O instead of CO_2. In any case the operation takes time for its carrying out, and during that time the temperature must be kept up. If, now, the gas is caused to impinge on a comparatively cold metal, a result will be obtained precisely the same as that got by holding a cold plate in the flame of a candle. The questions to be solved are somewhat complex, What are the least space and time in which complete combustion can be effected? Are these spaces and times compatible with boiler efficiency? Is perfect smokeless combustion worth the price that must be paid to secure it?

The first question is by far the most interesting. It can, however, scarcely be regarded as quite distinct from the second. The object of the furnace designer is to keep the products of coal distillation as hot as possible. The object of the boiler designer is to take all the heat out of them in the least practicable time. A compromise must be effected. The attempt at effecting it is the apology for a multitude of patents. Curious physical problems meet us at every turn. It is, for example, possible to burn carbon in the form of coke, so that it will produce only radiant heat. Now, if we use a small fire-box, a very good percentage of that heat will be utilised in making steam. Let now the fire-box be much larger, the area of the grate remaining the same. Then, although the heating surface is more considerable, the production of steam will be less. What becomes of the radiant heat lost? No one can say certainly. When fuel is burned in a separate retort or chamber, and the products of combustion are then brought into contact with boiler plates, there is always a loss of efficiency unless the temperature of the gas is extremely high. This lack of temperature is one of the reasons why retort firing, as it has been termed, is so seldom satisfactory. It will be seen, then, that some definite relation must be maintained which complies in a way not clearly understood with maximum efficiency, a compromise being made between the rate at which the fuel is burned, the temperature, the proximity of the boiler surface, and the dimensions of the retort and the grate. It does not appear that any fixed rule can be laid down. It does appear, however, that the United States Geological Survey have been able to arrive at very satisfactory results by direct experiment, and they have shown, as we have said above, that indifferent bituminous coal can be burned to great advantage by combining a chain travelling grate, a long firebrick arch, and a water-tube boiler. The unfortunate thing is that the conditions do not admit of being fulfilled in more than a comparatively small number of cases. It is, however, something to prove, as seems to have been done, that maximum steam production is not incompatible with the prevention of smoke—a point about which steam users as a body are somewhat sceptical.

The United States Geological Survey has not rested content with a consideration of the conditions favourable to combustion. Mr. R. B. Dole, a member of the staff, has made an estimate of the saving that may be effected by softening water used in the making of steam. He has taken as a basis 1000 indicated horse-power, for which he has allowed 100,000 gallons daily. Taking the Mauwee as a typical American river, he shows that it contains 360 parts of impurities to the million, of which 105 are suspended mud, and the rest carbonate or sulphate of lime, with a little magnesium. In six working days 1800 lb. of scale would be deposited in the boilers. He then gives calculations which he holds prove that an annual saving of £350 a year may be secured by softening the water, or about one half the cost of the requisite plant. In drawing a comparison he does not seem to have made any allowance for the good that may be done by blowing down or scumming, but he does include the cost of boiler compounds in his estimate. It is not necessary to accept his figures as conclusive, and yet perceive that much money is wasted by the use of hard water. The cost of softening it is not very great. Economy in this direction is "penny-wise-and-pound-foolish." There is, however, one consideration that is persistently overlooked by the apostles of water purification. It not infrequently happens that the wetted surfaces being deprived of a protective coating of scale, undergo rapid corrosion; while, in other cases, it has been said that flour deposit is formed with the most disastrous overheating results. In this, as in most other matters connected with the burning of coal and the generation of steam, caution, guided by experience, must be used to obtain an all-round satisfactory result. The chemist has always had a good deal to say about these things, for the most part quite useful. But it is well to keep in mind that the chemist has a way of looking at things which is very often not that of the man who pays the bills.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE paper read by Mr. L. A. Legros at last Friday's meeting of the Institution of Mechanical Engineers on "Type-casting and Composing Machinery" is considerably longer than the average, and resembles a book on the subject rather than a paper as the term is generally understood. Papers of the kind are, however excellent they may be, to be deprecated. They are suitable for the study, not for the lecture theatre, and are not in the least degree suitable for popular discussion. In view of its length we propose to give only a brief outline of the contents and to bring forward the author's main conclusions. Mr. Legros deals with those typographic surfaces which are produced directly by movable type or indirectly by means of movable matrices. The woodcut and the process block are neglected, as they do not present features of great mechanical interest. That part of the paper which deals with type-founding is interesting, and brings forward many points which should prove entertaining to almost any class of engineer. In justifying and in punch cutting, the author says, it is necessary to remember that type must not be made so as actually to be in alignment, or so that the characters shall be of equal size, but they must be made to appear so. Probably, the author continues, not one reader in a thousand appreciates the degree to which he is critical on size and alignment of type; the ease with which the eye detects want of alignment in two contiguous lines in the vernier here acts conversely in requiring it. A difference of one or two thousandths of an inch in alignment is readily apparent, and a difference of two or three thousandths of an inch in the size of a character is easily noticeable. It is shown that if the characters were made equal in their dimensions and true they would appear unequal. A good deal is given about machines and the processes employed for producing punches, matrices, and moulds, and the Benton-Waldo punch-cutting machine is illustrated and described. Several engraving machines for matrices are dealt with, and in connection with this part of the subject the author says the easiest method of making matrices for the simple type-casting machines is by electrolytic deposition of copper. A type of the desired character can be surrounded by two pieces of type-metal of similar form to the mould, and the face of the matrix is thus obtained true in the first place; the rough deposited sides of the matrix are filed or machined true subsequently. There can be no objection to the use of this method in cases of urgency or repetition—for example, when a punch has been damaged or broken—but it has been resorted to by less principled founders in copying the founts of the leading founders. For the matrices used in the later forms of type-casting machinery electrolytic copper is not generally hard enough to stand the wear, and the rough deposited surfaces require too much and too troublesome machining. A new process has recently been introduced in Germany by which the matrices are deposited in nickel much harder than the bronzes hitherto in use, and it appears to

the author that this may be of considerable importance in the manufacture of machine matrices.

Various kinds of moulds are then illustrated and described. The opinion is expressed that some of the greatest difficulties in the design of type-casting and matrix-composing machines are to be found in the pump. They are, the author states, of three kinds:—(*a*) freezing of the jet; (*b*) stoppage of the jet by accumulated oxide, which occurs in pumps of intermittent action; and (*c*) difficulty in getting rid of the air which fills the pump delivery pipe and mould, and causes blow-holes in the type. These difficulties, the paper states, are met by various expedients; the jet is separately heated by gas burners, and is so arranged that metal does not remain adhering to the orifice and there become oxidised; the plunger throughout the working length is immersed below the oxidised surface in the metal pot, and the surplus metal which is pumped is returned to the pot without exposure to the external air; the metal is delivered in large quantity and continuously, so that but little heat need be supplied by extra burners under the jet; and last, in some cases — *e.g.*, the Linotype machine—special provision is made for clearing the air by fine grooves cut on the face of the nozzle. The pump employed on the simplest type casters consists of a single plunger mechanically fitted and spring operated. The pressure on the plunger at the commencement of the stroke is about 60 lb. per square inch, and falls during the stroke. The Wicks rotary type-casting machine pump is then briefly described, also the Linotype pump, and the pump of the Monotype casting machine is referred to.

Next, a classification of type-casting and composing machinery is made. The machines are divided into four classes, according to the number of operations performed by each—*i.e.*, type-casting, composing, line-justifying, and distributing. Under the heading of Class I., the simplest machines which deal with one operation only are considered. In Class II. two-operation machines are considered, and in Classes III. and IV. three-operation and four-operation machines are dealt with respectively. Needless to say, a considerable portion of the paper is taken up in describing and illustrating the various machines which come under these four headings. Each of the above classes is also sub-divided. Thus in Class II. we have in section (*a*) machines in which composing and line-justifying only are effected—such, for example, as the Empire and Dow composing and line-justifying machines. We also have a section (*b*) in the same class which comprises those machines in which the cycle is divided into two parts. Generally the composition in such cases is effected on one machine and the record—in which the line-justification is provided for—is transferred to the second machine, on which the casting and line-justifying are performed automatically, the type being delivered in lines into a galley. In such machines the type is not usually intended to be distributed, but to be remelted. It follows that in general such machines are interdependent and designed to work together. Examples of this kind are to be found in the Lanston Monotype composing and casting machines, the Tachytype, and the Graphotype.

Having described the many machines coming under the heading given above, the author brings the paper to a close with a few remarks on the old and new methods. It does not appear probable to the author that the old method of casting single type and composing by hand can ever be entirely superseded by machine composition, as the bulk of display work and a large portion of scientific works cannot be so treated. In the case of most daily newspapers the whole of the ordinary matter, with much of the small type advertising, is set either in the form of slugs, or in the case of the more expensively-produced papers by means of other composing machines. A very large amount of high-class work for the better weekly periodicals, for magazines, for novels, and for text-books is still being performed by hand, but it is probable that this work also will be performed by machines in the near future, owing to the greater degree of perfection regularly obtainable in the product. One word of caution is offered by the author to those who think of competing in the field covered by these machines. The detail is so complex, and the difficulties met with in working out the machines are so numerous, that the time for which a patent is granted may easily be in greater part absorbed in experimenting before a commercial result is obtained.

The paper is illustrated by eight plates and seventy-eight drawings in the letterpress, and is accompanied by five appendices with three illustrations.

A vote of thanks having been passed, the discussion was opened by Mr. Maurice Clowes whose remarks were brief. He said that one of the most important questions, from the printer's standpoint, was the cost of the metal. That, in fact, was the great question. Mr. Legros had described a large number of different machines in his paper, and he thought that it would be extremely interesting to know which of these machines was the most economical as regards metal.

Mr. John Gilmore also confined his remarks to the metal. He thought that few people realised what the metal cost. Apart from the cost, there were certain difficulties in connection with the metal which required experience to overcome. It was necessary to know how to get the metal to run properly. The ordinary metal as used for type casting would not run properly unless it was at the correct temperature, and it had to be correctly mixed. This was the great secret of the whole process of type casting. The old type-founders used to test the temperature of the metal by dipping a piece of paper into it. In type casting, as carried out at the present time, it was necessary to work to very fine dimensions. As the author had shown in his paper, a uniform error of one ten-thousandth of an inch in parallelism would result in the end lines being inclined each over .01in. from the vertical. The speaker also referred to the importance of using a good flux. There was a flux which made the cost of the metal very low. That flux was bronze, but it was possible to experiment with it for three months before you got good type with it.

Mr. Worby Beaumont said that he would like to express his high appreciation of the remarkable book which Mr. Legros had brought before the Institution. He thought that although, as the paper showed, a great amount of attention had been paid to the subject, something might still be done to cheapen production. The author, he thought, had shown that there were improvements to be made. He (Mr. Beaumont) had worked with the author on tramways, gas engines, and motor vehicles. Mr. Legros had passed through the mill of the printing machine work, and he had then produced one of the best motor vehicles on the road. He could quite sympathise with the remarks of the author with regard to the shapes of the letters, and where he referred to kerned type, hair lines, and so on, and suggested the use of type which are pleasing and best for the eyesight. The paper showed that the engineer had successfully overcome many of the old difficulties which were experienced in the early days of printing. Before the paper was read he thought it possible that many who were present did not realise the difficulties which were presented in this branch of engineering. Mr. Beaumont also referred to the fact that it was quite noteworthy how printers' readers could detect any slight inaccuracy in a line of type. In the early part of the paper Mr. Legros had shown that it is necessary to introduce errors in the characters to make them of uniform appearance and pleasing to the observant eye. Continuing, the speaker referred to that part of the paper where type faces are dealt with and where the type faces are divided into main groups, *i.e.*, old style faces, modern faces, and fancy faces. The statement, "Our eyesight is one of the most precious assets, and the designer of type should therefore consider legibility as of greater importance than artistic effect," he thought was of importance. Turning to the question of metal, the speaker thought there was evidence in the paper of the difficulties met with in type founding; the metal which would flow into the finest possible line might be quite unsatisfactory in other respects.

Mr. A. E. Giles first expressed his gratitude to the Institution for inviting the printers to the meeting. He thought that the printers owed a great deal to the engineers for the manner in which they had grappled with the problem of constructing efficient printing machinery. He did not think that the cost of the metal was such an important item as one of the previous speakers had suggested. The principal trouble experienced with the metal was getting it to run properly into the mould. In the hands of inexperienced workmen a considerable amount of inconvenience arose from this. At one time it was customary to entrust the work of melting the metal to anybody. This, however, proved a great mistake, and it soon became evident that the work required an experienced man. His firm had experienced no trouble after giving the work to the right man. Returning to the cost of the metal, the speaker said it did not exceed 8d. per pound. In his own case the runs were short. With the single letter system it was much easier to make corrections than with the Linotype. The printer wanted to be certain of two things, namely, the height of page and alignment. At present he thought the printer's principal difficulties were high quads and spaces. In conclusion, he thought that when the engineers could give the printers low quads and spaces they would be satisfied.

Mr. W. H. Lock was the next speaker. He thought that the paper was an excellent one, but it had a wrong title. While he was sure that the preparation of the paper had involved a tremendous amount of work, it by no means covered the subject which it had for a title. The paper was that of an engineer who had incidentally come into contact with the subject, and who had grasped it where he had touched it. He would not like the engineers who were not associated with the work to think that the paper covered the whole field. He would have liked to have seen something in the paper of a historical character. The author, he thought, might have given an account of some of the early difficulties and the various attempts which had been made to overcome them. Linotype came under the heading of slug machines. Engineers had attempted many processes of printing, but there were at the present time two processes which were commonly used. There was the older system where each letter was set up separately, and the slug machines, where the type was produced in a complete block. He belonged to those who advocated the slug system. The speaker then went on to refer to one or two points in the paper which he did not consider quite accurate. Some of these points, as the speaker admitted, were not of great importance. A sectional drawing of the pump nozzle of a Linotype machine, given in the paper, was one thing which he complained of as not being quite accurate. In another part of the paper the author stated that "the rate of output of the Linotype machine is generally taken at 6000 ens per hour, this representing the normal rate of an average compositor." Under good conditions, however, the compositor can set from 7000 to 8000 ens. The speaker was of opinion that these figures might be increased very considerably. In another part of the paper the author had stated that the Monoline machine was of Canadian origin, whereas, as a matter of fact, it emanated from America. Again, near the end of the paper the author spoke of the advantages of casting separate type being many. Mr. Legros here said that "corrections can be made by hand, and away from the machine if necessary, whereas in the slug machines it is necessary to recast the whole of the line, even when the corrections consist only of two transposed letters or a point omitted. The depth of the strike can be deeper, and therefore permits a hard metal to be used, whereas the metal used in the slug machines and in those similar to the Monotype must necessarily be soft." The speaker thought that these advantages were all right in theory, but not in practice. The Linotype machine, he thought, was the best, and corrections could be made quicker than with the older method of separate type. Lastly, the speaker referred to the end of the paper, where the author offered a word of caution to those who think of competing in the field covered by printing machines. Here the author had said the detail is so complex, and the difficulties met with in working out the machines are so numerous, that the time for which a patent is granted may easily be in greater part absorbed in experiment before a commercial result is obtained. He—Mr. Lock—thought that a truer statement than this had never been made.

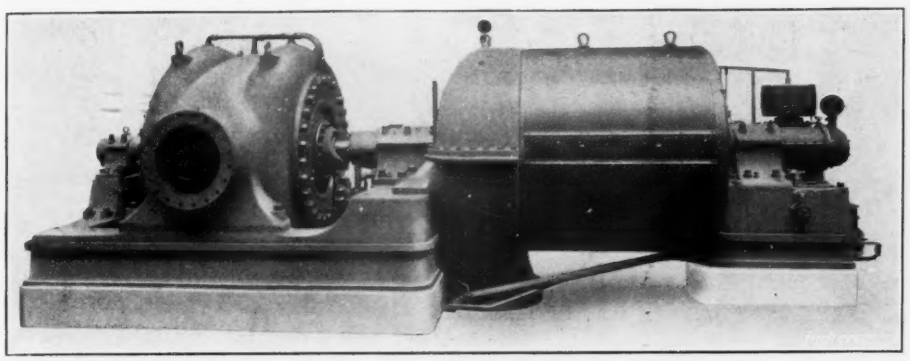
Mr. H. Longhurst referred to that part of the paper in which the author dealt with the pumps used in connection with type-casting and matrix composing machines. In this part of the paper Mr. Legros had made reference to a type-caster designed by Sir H. Bessemer, in which he created a vacuum in the mould immediately before casting, with the object of getting rid of the air which fills the pump delivery pipe and mould, and causes blow-holes in the type. The speaker thought that this was an important question, and if the system could be applied it would be a great advantage. He would be glad if Mr. Legros would explain how the vacuum was used, and why the system had gone out of existence.

The last speaker was Mr. Frederick Wicks, who thought the paper the best contribution of its kind. He did not propose to put forward any criticism, as he did not think that it was called for. The paper, he thought, showed clearly the difficulties surrounding the subject. When the subject first came under his notice he came to the conclusion that the first thing to be done to effect economy in printing was to do away with the distribution of type and make type so quickly that it could be replaced by new type for less than the cost of distributing. He doubted whether there were more than eight type-founders in the United Kingdom at the present time. He had never been over one of these type-founding establishments. It was a secret industry. In bringing out his type-casting machine for the rapid production of type the most difficult obstacle met with was the thermal problem. At first he had some difficulty in devising a means of getting the metal to cool quickly enough to enable the type to be turned out rapidly. Lord Kelvin had taken a great interest in his early experiments, and more particularly in the thermal part of the problem. He thought that our knowledge of the passage of heat through metals up to a few years ago was somewhat inadequate. With the method he had adopted the metal cooled in .03 of a second, and was ejected at a temperature of 80 deg., and turned out pica twelve times as fast as the single mould type-casting machine. The thermal problem to which he had referred had been solved by pouring the metal into a mould which was cooled by water circulation. With most examples of casting the mould was heated, but this was one instance in which the work was done in a cold mould.

Mr. Legros then replied. He thanked the various speakers for their kind remarks concerning the paper. The points raised by the first two speakers were both important; the use of phosphor bronze as a flux was good practice, provided, as Mr. Gilmore had said, it is used in the right way. As regarded the remarks of Mr. Beaumont concerning introducing errors in the dimensions of the characters to make them appear uniform, he (Mr. Legros) had tried to make the point clear, and he hoped that he had succeeded in doing so. Mr. Giles had expressed the opinion that the cost of the metal was not a serious consideration, but thought the height of page and alignment were what the printer wanted to be sure of. These latter points were, of course, of importance. Mr. Lock had said that the paper by no means covered the whole field of the subject. It was not his intention that it should do so. He would point out that there was very little literature on the subject, and there was plenty of field for Mr. Lock or anyone else associated with the work to add to the existing literature of this kind. A paper on the Linotype machine alone would make a good contribution. Referring to the section of the pump nozzle of a Linotype machine given in the paper, which Mr. Lock maintained was inaccurate, the speaker said that he thought it represented a pump of a standard machine. Coming to the question of the speed of Linotype machines, the speaker said that Mr. Lock was in a better position to quote on this part of the subject than himself, and if the figures given in the paper were too low, he would be glad if Mr. Lock would supply the correct speeds, so that the figures might be altered. Mr. Lock had also objected to the statement that the Monoline machine was of Canadian origin; he would be glad to know the real inventor's name if this were incorrect. In his remarks, Mr. Lock had also expressed the wish for some historical information on the subject; but it was against the rules of the Institution to go into historical details in papers. The papers had to contain new information rather than old. If Mr. Lock wanted to gain information concerning the numerous patents which had been taken out in connection with printing machinery, for the sum of 2s. 6d. he could obtain from the Patent-office a book of abridged patent specifications dealing exclusively with the subject. The book was as big as the "Post-office Directory." It was against the rules of the Institution to discuss patents. The speaker then referred to the remarks of Mr. H. Longhurst. He did not know exactly what Sir Henry Bessemer did with regard to creating a vacuum in the mould with the object of getting rid of blow-holes. These blow-holes were a constant trouble, and it would be interesting to know what results Sir Henry Bessemer got. In dealing with the remarks of Mr. Wicks, the speaker referred to the difference in the appearance of a slug cast in a cold mould and that of one cast in a hot mould. It was quite easy to distinguish the difference.

STEAM TURBO HIGH-LIFT PUMP

MATHER AND PLATT, LIMITED, MANCHESTER, ENGINEERS



STEAM TURBO HIGH-LIFT PUMP.

FOR the Montreal Water and Power Company the firm of Mather and Platt, Limited, Manchester, has recently constructed a large centrifugal pump operated by a steam turbine. This makes the fourth pumping plant which Messrs. Mather and Platt have supplied to the above company. Before commencing a description of the new apparatus it may be of interest to our readers to have the leading particulars of the earlier installations. The first plant consists of a two-chamber pump operated by a three-phase motor, the latter working at 2200 volts and 63 cycles per second. The pump is designed to raise 3820 gallons per minute to a total head of 300ft. when running at a speed of 740 revolutions per minute. The work thus done represents about 450 brake horse-power, and the over-all dimensions of the plant are 17ft. 6in. long, 6ft. 6in. high, and 6ft. 3in. wide. The second pump for the same company is capable of delivering 4500 gallons per minute against a total head of 300ft. This machine is not only coupled to a three-phase electric motor, but also at the other end to a steam engine, an arrangement which necessitated a much lower pump speed, namely, 335 revolutions per minute and a consequent increase in the number of chambers. The engine is of the triple-expansion type, built by Bellis and Morcom, and has been provided as a stand-by because the supply of electric current is not at all times sufficient to drive the electric motor. The work of driving is divided between the motor and the steam engine as follows:—The steam engine drives for four or five hours per day during five days each week, and for the remainder of the week the pump is driven by the motor. The change over is effected by unlacing the belts of the flexible coupling, and is done in a few minutes. The third pumping set is capable of discharging 10,500 gallons per minute against a head of 400ft., and is operated by a three-phase motor.

The fourth set recently supplied differs from all of the other three, both in respect of the motive mechanism and the construction of the pump. The top engraving is a general view of the steam turbine and pump complete, while Figs. 1 and 2 represent a sectional elevation of the two parts and a transverse section through the pump itself. The contract was for a turbine-driven pump of the same capacity as the third set, namely, to deliver 10,500 gallons per minute against a head of 400ft. The feature of Mather and Platt's turbine pump is that it consists of one or more sets of vanes or impellers, each set running in its own chamber but upon a common shaft, the delivery pressure of the liquid varying directly as the number of chambers used. In the set under notice, however, it will be seen on reference to the drawing, Fig. 1, that the work is effected by two impellers A B working in parallel instead of in series. This alteration in the construction of the pump is brought about by the relatively high speed of rotation of the turbine, namely, 1500 revolutions per minute, coupled with the large volume of water to be dealt with in relation to the head. The water enters the central chamber of the pump at a slight head—actually about 10ft.—and is taken up axially by the two phosphor-bronze impellers, which are secured on the shaft. The external construction of the pump is such that the water is split up into four streams, two to each impeller, as shown by the arrows. This keeps the impellers in lateral equilibrium, and prevents end thrust. From each impeller the water is thrown in two converging streams at a very high peripheral speed through expanding passages in stationary guide rings, in which it loses some of its velocity, while gaining correspondingly in head or pressure. The construction of the pump is clearly shown in the sectional views. The water is discharged into an annular chamber, C from which it is conveyed along the pipe lines. The guide passages are so designed that the water in these pumps is not compelled to undergo any sudden change of direction. It will be observed that there are no moving parts in frictional contact except the spindle in the long and well lubricated bearings, and the edges of the impeller bosses against the bushes. The main D bearing is fitted with forced lubrication, and is, like the bearings of the steam turbine, water jacketed.

After imparting motion to this wheel G, the steam is caused to flow successively through orifices cast in the diaphragms separating each of the other fifteen wheels. As the steam pressure falls in its passage from one wheel to the next its volume increases. To compensate for loss of pressure the number of passages or nozzles in the diaphragms is increased step by step. After going through eight stages of expansion in the high-pressure end of the machine, a similar process is repeated in the low-pressure end. The casing and eight wheels of this end are considerably increased in diameter. The first four wheels are of identical size, but the last four wheels are gradually enlarged as shown. The first five high-pressure diaphragms are of cast steel, and the remainder are of cast iron with grooved bronze bushes to prevent leakage of steam through the centre, and the orifices for the steam are cast in them. The wheels are made of nickel steel, and are provided with a number of holes through them, the object of which is to balance the pressure on each side when the steam is suddenly shut down. The blades are of sheet nickel steel bent to an elliptical curvature and separated, where they enter the wheel, by distance pieces. The whole of the blades J and distance pieces are firmly secured by means of a ring K, which is riveted on the wheel. Mention should not be omitted of a by-pass L, which admits high-pressure steam through holes in the fourth high-pressure diaphragm flange for giving increased torque when starting.

The whole of the sixteen wheels are secured on the hollow shaft by feathers M held by countersunk screws, and their flanges fit close up to each other between the end flanges on the shaft, the latter being increased in diameter in steps from 9⅜in. at the high-pressure end to 10in. at the low-pressure end, to facilitate getting the wheels on and off. The length of the shaft so taken up is about 5ft. 4in. The casing is divided in two along the horizontal centre line, so that the top half can be readily removed by eye-bolts. The bearings are distinct from the turbine casing. They are provided with a system of forced lubrication, and are water-cooled. They are lined with white metal, and a thrust block of the marine type is fitted at the low-pressure end nearest the pump. The latter is coupled up to the steam turbine shaft by a flanged coupling, which is enclosed within a split casing. The steam supply is regulated by a stop valve of special design. From this valve the steam flows to a throttle valve, which is under the control of a Chorlton-Whitehead governor shown in Fig. 3. Externally the governor is of cylindrical form. Internally it contains a chamber filled with oil in which the various working parts are immersed, and the connection to the valve gear is made from a spindle projecting through the top. The construction will be readily followed by referring to the sectional views

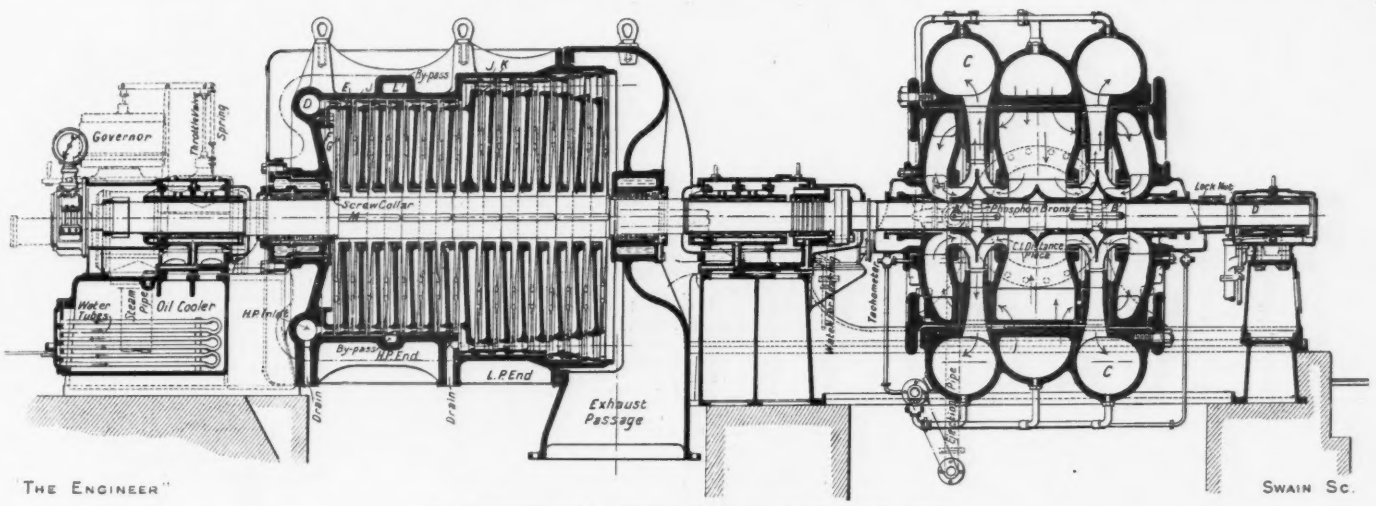


Fig. 1—LONGITUDINAL SECTION THROUGH TURBINE AND PUMP

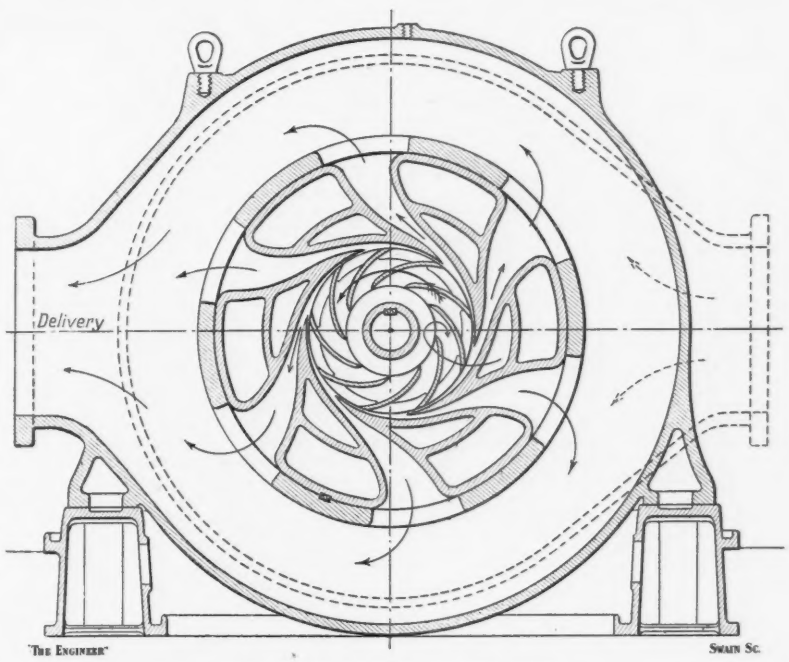


Fig. 2—CROSS SECTION THROUGH PUMP

The turbine is of the Zoelly pattern, capable of giving 1800 maximum horse-power at 1500 revolutions per minute, with steam at 165 lb. per square inch and condensing. It has sixteen wheels, and the steam, superheated 150 deg. Fah., is led to the first wheel from the annular passage D through numerous holes E in the circular plate F shown on the left.

which clearly show the different parts in elevation and plan. A A^1 are two spindles pivoted as shown, and at either end of them is keyed a lever C C^1 for carrying the governor weights E E^1. In between the two is a lever D on each spindle, and by these the movement of the weights is communicated to the external rod. The weights are bored out as shown in the plan to contain springs F which oppose the centrifugal action of the weights. The outer ends of these springs are tied by rods passing through the weights themselves. By this means friction is reduced to a minimum, and the levers and pins are relieved of all thrust except that which is required to operate the controlling gear. It will be observed that the spring F on one side is divided into two unequal halves, separated by a dash-pot piston G. The dash-pot is provided with a small adjustable valve J which provides communication for the oil between the dash-pot and the body of the governor. When this is wide open oil can flow freely to the interior, and the two halves of the spring will move as one whole, being equivalent to the single spring in the other weight. The two are thus designed to counteract exactly the centrifugal action of the weights in all positions when running at a constant speed, and the action of the governor is thus isochronous. By closing the valve J completely the action of the governor will be rendered too stable for governing closely. It therefore becomes necessary to adjust the valve so that the governor will be in a state of equilibrium in any position after a certain time has elapsed, allowing the

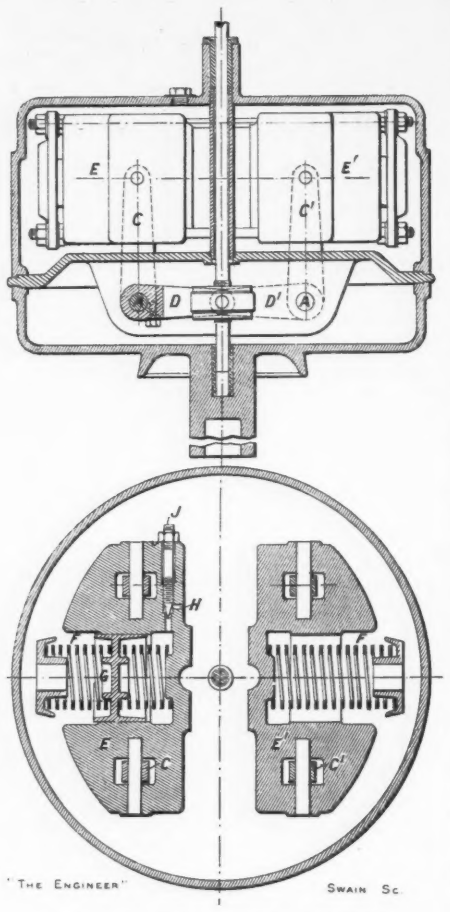


Fig. 3—CHORLTON-WHITEHEAD GOVERNOR

piston G to move to its correct position; or, expressed otherwise, the governor's action will still be isochronous, subject to a certain time lag amounting in practice to two or three seconds. The governor is made by Ashworth and Parker, Limited, Bury. The length of the complete plant over all is 25ft.

POST-OFFICE TENDER FOR URUGUAY.

A LITTLE vessel called the Correo del Uruguay has recently been built for the Uruguayan Post-office service by Yarrow and Co., Limited, of Glasgow, formerly of Poplar, London. The vessel, which is illustrated above, is 97ft. long overall by 14ft. 6in. beam, and has been built for the special service of meeting the mail steamers from Europe in Montevideo roads, and bringing ashore and taking off the mails.

The hull is exceptionally strongly built of galvanised steel, and is divided by six water-tight bulkheads into seven compartments, and is fitted with a strong rubbing piece all round to enable the vessel to lie alongside the mail steamer in rough weather. The forward compartment is used as a chain locker and store room. The second compartment is fitted up as crew's quarters, and contains sleeping bunks for eight men. The third compartment is intended for the heavy mails and parcels. To facilitate the handling of these, a derrick suitable for lifting half a ton is fitted to the mast. The fourth and fifth compartments are the boiler and engine rooms respectively. The sixth compartment is intended for the lighter description of mails, and the seventh compartment is a store room. The forward deck cabin is fitted up for the assistant Post-office officials, and contains four sleeping berths. Amidship opposite the funnel on the starboard side is the galley, and on the port side the water-closet. The forward part of the after deck house is fitted up as a sorting room for mails. The middle part is a saloon for the three senior Post-office officials, and the after part is sleeping accommodation for these officers. A 12ft. boat fitted with air tanks is carried on davits on the port side. The cabins

POST-OFFICE TENDER FOR URUGUAY

YARROW AND CO., LIMITED, GLASGOW, ENGINEERS

and machinery spaces are fitted throughout with electric light, and a small searchlight is installed over the steering station forward, and can be manipulated by the steersman. A 37 mm. Armstrong quick-firing gun is placed on the deck forward, and a magazine for ammunition is provided. A steam ejector is fitted to each of the five main compartments, and all the compartments have hand pumps. The machinery consists of a "Yarrow" patented water-tube boiler arranged for forced draught, and one set of triple-expansion engines which are carefully balanced. There is a surface condenser. The air pump for maintaining the vacuum is driven off the end of the main engine shaft. There is one main and one auxiliary feed pump, the former being made by Messrs. Caird and Rayner, and fixed in the engine room. There are also placed in the engine-room a small fan engine for driving the fan for forced draught, and an independent circulating pump and engine. The dynamo and engine by Messrs. Allen, of Bedford, is also installed in the engine-room. The blow-off pressure of the safety valve is 250 lb. to the square inch, but the pressure necessary to obtain the contract speed was, we are informed, considerably less than this. The official trial of this boat was run on the 2nd November, in the presence of Mr. Francisco de Tezanos, Uruguayan Consul at Glasgow, and Messrs. Mollison and Thomas, of Lloyd's. Six runs over the measured mile at Skelmorlie were made, and a mean speed of 11.484 knots was obtained, being a knot in excess of the contract speed. The pressure required to obtain this speed is, as stated above, considerably below the maximum pressure for which the machinery was designed. Two additional runs were made at the full pressure of 250 lb., giving a mean speed of 13.362 knots. The vessel will be shipped in its entire state for Montevideo.

AMERICAN ENGINEERING NEWS.

Fueling barges for Havana Harbour.—For coaling large steamers at the port of Havana, Cuba, some barges are used which carry the coal and have machinery for delivering it to the bunker hatches in the sides or decks of the steamers. At the bottom of the hold is a conduit having traps in the floors of the coal compartments above, and in this conduit runs an endless chain conveyor. The conveyor has two chains carrying V-shaped buckets 20in. square and 36in. apart. The conduit is 130ft. long, and at each end is a trunk or shaft rising to the deck. The conveyor is carried up vertically through the forward trunk and up through a steel tower in the bow. At the top of this the conveyor makes a short horizontal turn, and here the buckets are tripped and inverted, discharging their contents into a hopper from which an adjustable inclined 15in. pipe or spout, 60ft. long, leads to the bunker hatch. The conveyor then doubles upon itself horizontally, descends through the tower, passes along the deck, and descends through the stern trunk to the conduit. The barge is moored with its bow to the side of the steamer, so that it does not interfere with boats or cargo lighters alongside. The conveyor travels at a speed of 120ft. per minute. It can deliver 100 tons of coal per hour if run continuously, but in actual service it has to be run intermittently to allow of proper trimming of the coal in the bunkers. As this involves frequent starting of the conveyor under full load, a 35 horse-power engine is used to operate it. Where time is important, as when liners stop for coal only, 1200 tons have been delivered in eight hours.

Testing the hardness of metals.—The Shore scleroscope, recently introduced in the United States, is a machine for effecting a scientifically accurate measure of the hardness of metals. In a vertical glass tube is a cylindrical weight or monkey, and at the back of the tube is a graduated scale. The tube is open at the bottom, and is set over the piece to be tested. At the top of the tube is an india-rubber bulb; by compressing this and then releasing it, the hammer is drawn up the tube and held at the top by a trip. When released, the hammer falls freely, strikes the test piece and rebounds. The height of the rebound is the measure of the hardness of the test piece, and this height is read from the scale, a magnifying glass being used, if necessary, to assist the eye. A steel ball was first used for striking, but did not deliver a sufficiently intense blow. After some experimenting, a cylindrical form was adopted, but the striking end is tapered to a reduced area, so that the intensity of the blow is very severe as compared with the area of impact. The force of the blow is as high as 75,000 lb. per square inch. Where a less intense blow is desired, a hammer with a rounded end is used. Considerable difficulty was experienced in procuring a material for the point of the hammer which would withstand the impact. Investigation into the treatment of tool steel resulted in the production of a steel that would stand up under the severe service; and the investigation was carried on largely with the assistance of the instrument itself. Testing hardened steel for crystalline structure, and testing the decrease in hardness due to overheating are among the special purposes of the machine.

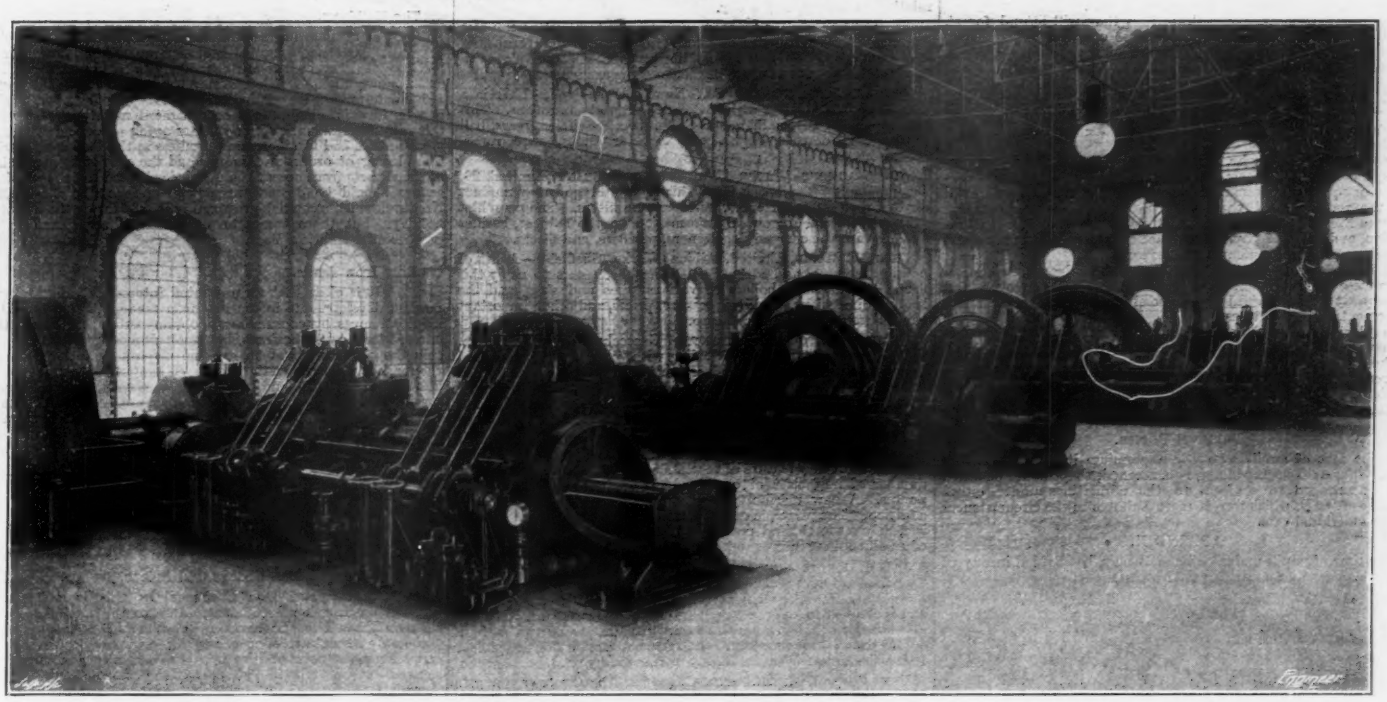
The largest chimney in the world.—By far the largest chimney in the world has been recently completed at Great Falls, to carry off the gases from the smelting plant of the Consolidated Copper and Silver Mining Company. The chimney is on a hill about 250ft. above the plant, and has a height of 506ft. Provision for an additional 60ft. is made, in case a stronger draught should be required in the future. The chimney has an octagonal base 46ft. high, in two sides of which are the openings for the forked end of the gas flue. The base diameter is 78ft. 6in., at the beginning of the cylindrical section it is 74ft., these being outside measurements. The inside diameter at the top is 50ft. The wall tapers from 54in. thick at the bottom of the cylindrical section to 18½in. at the top, but at the extreme top the bricks are corbelled out to give a coping thickness of 44in. The batter of the wall is 8 per cent. for the octagonal portion, 7 per cent. for 180ft., 4 per cent. for 100ft., and 2 per cent. for the remaining 180ft. The foundation is of concrete. The chimney is built of Custodis perforated radial bricks, made at the site in a special plant utilising the local shale. The bricks are 4⅜in. thick, 6¼in. wide at the butt, and from 4in. to 10⅜in. long. They are laid in cement mortar, and pointed with acid-proof mortar for 50ft. below the top. The interior has a 4in. lining of acid-proof brick, with a 2in. air space between this and the main wall. This lining extends to the top of the chimney. The flue is 33ft by 21ft. from the smelter to the dust-catching chamber, which is 176ft. wide, 21ft. high and 480ft. long. Hoppers in the chamber discharge the dust into wagons in a 12ft. tunnel under the flue. From this chamber to the chimney the flue is 48ft. by 21ft. It is built of steel columns and beams, with brick walls and roof and a concrete casing over the steel work.

Handling concrete by belt conveyors.—At one point in the New York barge canal, now being built from the Hudson River to Lake Erie, there is a group of locks and other structures requiring over 250,000 cubic yards of concrete. Special methods were devised by the contractors to handle efficiently and economically the enormous amount of raw material and concrete, and the plant includes a number of belt conveyors. At the concrete mixing plant there are four sidings—one each for railway wagons with cement, sand, and stone, and one for empty wagons. The stone and sand are dropped into hoppers under the sidings and carried by a system of belt conveyors to the storage bins. Other belts under these bins carry the materials to the charging floor of the concrete mixer. Another conveyor carries the sacks of cement to the same floor. The plant is capable of handling one cubic yard of concrete per minute, but the maximum in actual work is 450 yards in an eight-hour day. The concrete mixer delivers its product to a series of belt conveyors, each running at 450ft. per minute. The first one is 80ft. long, and discharges into a hopper which feeds the second conveyor, 150ft. long. The third conveyor extends through the lock and is 600ft. long. The timber trestle which carries this last carries also a portable tripping machine by which the concrete is unloaded at any part of the conveyor, and delivered upon a swinging lateral belt conveyor which finally discharges the concrete into the moulds or forms for the walls. Spouts attached to the head of the jib carrying this conveyor, serve to deposit the concrete smoothly and steadily and to distribute it within the forms.

CRYSTAL PALACE ENGINEERING SCHOOL.—The Wilson Premiums for the best papers read before the Crystal Palace Engineering Society during the present session have been awarded by the Council to two students, namely, W. N. Green, for his paper on "Permanent Way," and R. S. R. Scrivener, for his paper on "Indian Railways." Other papers read during the session were "Gold Mining," by E. C. B. Hawkes, "Chain Surveying," by W. S. Liddle, and "Weirs and Dams," by R. A. Wallace. The Premiums were presented to Messrs. Green and Scrivener by Sir John Jackson, on the occasion of the 108th distribution of certificates at the above school on Friday, December 18th, at which he presided

GAS ENGINE POWER STATION OF THE ESCHWEILER BERGWERKSVEREIN

MASCHINENFABRIK AUGSBURG-NURNBERG, ENGINEERS



A COKE OVEN GAS ENGINE PLANT.

THE development of the gas engine power station at the pit "Anna 2" of the Eschweiler Bergwerksverein at Alsdorf near Aix-la-Chapelle affords an excellent example of how a progressive colliery can cover all its power requirements in a practical and economical way by taking full advantage of recent engineering progress. At this colliery, as at most others, the coke oven gas was until recently burned under boilers delivering the steam required by the different steam engines about the works. These comparatively small steam engine plants needed each of them special spare engines, and therefore the maintenance and working costs were high. As a steam engine of best design can transform only 15 per cent. maximum of the heat value of the gas into power without even reckoning the great condensing loss in the long pipes, the heat value of the gas was not used to anything corresponding to its maximum. Satisfactory gas engines give 30 per cent. of the heat value of the gases as power, the total efficiency of a gas engine plant is therefore practically more than double that of a steam plant. Recognising these facts, a decision was some six years ago arrived at gradually to scrap the various steam engines, and to erect a large power station of gas engines for driving dynamos. The gas engines were to be driven by coke oven gas, which was sufficiently free from tar since a by-product recovery plant was provided. A special cleaning plant of iron oxide ore was erected to extract sulphur from the gas, such sulphur varying in quantity according to the coal used. The installation was commenced by the provision of two gas engines of 500 brake horse-power, both of which were ordered from the Maschinenfabrik Augsburg-Nurnberg, for direct coupling with the three-phase dynamo of 500 volts which was supplied by the Allgemeine Elektricitats-Gesellschaft, of Berlin, and the plant was set to work during 1904. The practical and scientific conditions for good parallel running were fixed by the M.A.N. and the A.E.G. after exhaustive investigations and tests. The engines gave such satisfactory results that it was decided to erect larger units. During 1904 and 1905, two engines of 1000 brake horse-power each and one of 1200 brake horse-power, and in 1907 two twin tandem engines of 2400 to 2600 brake horse-power, all of the "Nurnberg" type, were erected. These have been followed during the past few months by a further order to the M.A.N. for two engines of 2600 to 2800 brake horse-power each, so that the output now is 14,500 to 15,000 brake horse-power, which total represents about twice the power formerly produced by steam plant, and it largely exceeds the power requirements of the colliery itself. One portion of the current is therefore used at the "Edward" pit, where the winding engine is driven by means of an Ilgner transformer, the current having a tension of 5500 volts. Another part of the power of some 3000 brake horse-power is transformed from 5500 to 35,000 volts and is sent to the "Eschweiler" pit about eleven miles distant, where it is used as a reserve for the pit pumps and sundry other purposes. It is further intended to take about 1500 to 2000 brake horse-power out of this high tension wire to the "Maria" pit about one and a-half miles away.

The illustration above and the supplement show the gas engine power station of the Eschweiler Bergwerksverein, which, it is claimed, will be, when the engines now on order are delivered, the largest coke oven gas engine plant in the world. It should be stated that the 342 coke ovens for the Eschweiler Bergwerksverein were supplied by the Koppers' Coke Oven and By-Product Company. The following table gives the result of tests which Professor Lange, of the Technical University at Aix-la-Chapelle, took with the two 2400 brake horse-power gas engines at Alsdorf. These tests were made on Sundays, it was, therefore, not possible to overload the engines, but preliminary trials had shown an overload capacity of 16 per cent. At the same time, the reliable parallel running of the gas engine combined in every possible way, and under different loads was well proved.

Results.	Test 1.	Test 2.
Outputs in kilowatts	1530	1554
Heat consumption guaranteed in B.Th.U. per I.H.P. an hour	8000 (2000 cal.)	8000 (2000 cal.)
Tested consumption in B.Th.U. per I.H.P. per hour	6835 (1737 cal.)	6867 (1736 cal.)
Total efficiency, taking the efficiency of the dynamo 0.945	0.794	0.794
Proved efficiency at full load	0.844	0.857

On a later date Professor Lange continued his investigations in order to ascertain how this engine, which was designed for coke oven gas, would work driven by producer gas made of coke. Owing to the quality regulation of the M.A.N., it was proved that the engine was able to work at full load without any alteration of the valves or governing gear either driven by coke oven gas of 340 to 450 B.Th.U. per cubic foot (3000-4000 W.E. per cubic metre) heat value, or by producer gas of 113 B.Th.U. per cubic foot (1000 W.E. per cubic metre), figures which would not be obtainable with other quantity regulation so generally used. The producer gas plant is erected as a reserve in case of strikes, or if the coal production and the working of the coke ovens is interrupted for any other reason. The working results obtained with this important gas engine installation of the Eschweiler Bergwerksverein prove conclusively the great economies derived from large gas engines for up-to-date colliery work, and, as at several collieries in this country new coke ovens with by-product recovery and surplus gas plants are now being built, and others under consideration, the question of the adoption of suitable gas engines would appear to merit serious attention.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

REPORT OF EDUCATIONAL COMMITTEE.*

THE Committee is, in the first place, of opinion that youths intending to qualify as artisans should receive while at school the best training possible, including, when practicable, some instruction in elementary science, that more attention than at present should be given in schools to the inculcation of habits of order, perseverance, and good conduct, and that apprentices should be encouraged to continue their studies and the cultivation of these habits during apprenticeship by a system of awards offered by their employers. Hence the regulations proposed hereafter for ordinary apprentices.

The Committee, in the second place, believes that industrial conditions in this country now call for some change in the methods of selecting and training those destined to work in the higher branches of engineering and shipbuilding. The Committee feels that, if we are to maintain our position in those industries in which science now plays so important a part, more vigorous efforts than hitherto must be made to secure the highest and most suitable education and training for adequate numbers of selected youths. As it is obvious that the attitude of employers will largely determine whether such youths will be induced to equip themselves for competition on equal terms with the more highly trained young men of other nationalities, the Committee has ventured to put its recommendations as to pupils in the form of regulations suitable for use in works. It is earnestly hoped that, in the interests of all concerned—both employers and employed—these regulations will be generally adopted.

The object of the increased pay attached, in the regulations for pupils, to educational qualifications is intended to serve as an immediate inducement for youths voluntarily to undertake the severe discipline, self-denial, and hard mental work entailed by systematic study in the higher branches of their profession.

As regards probable numbers of pupils, it is estimated that the object aimed at would be attained if each firm were to take, say, an average of two fresh pupils each year—large works taking more and small works fewer—making for a six years' pupilage, three of which will be spent at college, a total number of six pupils in the works and office at any one time, the total extra cost in wages being estimated at something like £40 per annum, on an average, for each firm.

To obviate confusion and misapprehension, the proposed regulations are presented under two heads—first, those dealing with ordinary apprentices, and secondly, those dealing with pupils.

The term "apprentice" is to be understood to refer to those who enter the works to learn one or other of the trades or handicrafts therein practised, who serve the usual term of apprenticeship in the works, who may or may not attend evening science classes, but who do not attend a systematic University College day course of instruction during their apprenticeship, and whose object is to qualify as tradesmen, mechanics, or artisans.

The term "pupil" is, on the other hand, understood to refer exclusively to those who enter works, not with the sole view of thoroughly fitting themselves for ultimately rising into the higher branches of the profession of engineering or shipbuilding, *e.g.*, draughtsmen, managers, superintendents, inspectors, consulting experts, employers, &c., who may or may not attend evening science classes, but who either have already attended, or will attend, a systematic course of instruction at University College day classes.

REGULATIONS.

I.—REGULATIONS FOR APPRENTICES.

In starting apprentices, preference will be given to applicants who bring the best certificates of conduct and character, and the highest school-leaving certificates.

At the end of September in each year each apprentice will be awarded marks as follows:—

For each approved examination in science or in mathematics: see Schedule A.	
For time-keeping: a maximum of	120
For good conduct, industry, and progress in the workshops: a maximum of	60

Marks for time-keeping will be deducted at the rate of one mark for every hour lost, but no deduction will be made for special leave, or for sickness, if certified by a doctor.

Conduct marks will be awarded quarterly on the basis of the following scale for the complete year:—

Very good .. 60 marks per annum .. Good .. .. 44 marks per annum
Fair .. .. 28 ,, ,, .. Moderate .. 16 ,, ,,

An apprentice obtaining 160 marks in the aggregate will receive a bonus as per Schedule B.

For marks in excess of 160 the bonus will be proportionately increased.

No payment under this scheme will be made to apprentices obtaining less than 160 total marks, or who fail to obtain 70 marks for time-keeping.

Apprentices who fail to obtain a reasonable number of marks for time-keeping, good conduct, industry, and progress will be subject to dismissal.

The apprentice in each shop having the highest number of marks may choose any other shop he wishes for advancement, provided there is a vacancy therein. Vacancies in the drawing-office will, at the discretion of the firm, be filled by the apprentices having the highest number of marks.

Apprentices who have served under one year will receive bonuses calculated *pro rata* for the time they have served.

Should an apprentice during the early years of his apprenticeship show exceptional ability in his studies at the evening classes, and have obtained a sufficiency of marks for timekeeping, good conduct, and progress in the works, he may, at the discretion of the firm, be allowed to attend a session at college day classes.

Marks will only be given for examinations passed in the year for which the certificate is issued.

Students will be expected to show improvement each year in the results of their examinations, and the full marks allowed for any given pass can only be obtained in one year. Should the student only succeed in obtaining the same pass a second time, the marks obtainable will be reduced by 50 per cent.

A complete list of the apprentices in order of merit, showing the timekeeping and industry marks gained, with the greatest possible obtainable in each of these, also the class marks gained and the relative position of each apprentice, will be sent annually to each parent or guardian.

When the apprenticeship has been satisfactorily completed a certificate will be given, recording the position obtained by the apprentice each year, and also giving details of the examinations passed during apprenticeship.

II.—REGULATIONS FOR PUPILS.

Scheme A.—Youths who have passed through a three or four years' engineering day course at an University College, and who have obtained therefrom either an approved certificate, or a pass degree in engineering science, or in naval architecture, may be admitted into the works as pupils.

They will serve a three years' pupilage, and for their first year the scale of pay will be that of an ordinary apprentice of the third year. The scale of pay for their last two years will be that of ordinary apprentices of the fourth and fifth years, plus 3s. and 5s. per week respectively.

Those who hold a degree with honours may be admitted on the same conditions as the above, but the scale of pay for the last two years will be increased by 4s. and 7s. per week, instead of 3s. and 5s.

Scheme B.—Youths who desire to combine workshop experience

* Issued in December, 1903; amended in December, 1908.

with college study, and who hold no certificate or degree from an University College, may be admitted to the works as pupils on the production of evidence that they have received a sufficient preparatory education. A certificate showing they have passed the matriculation examination required for graduation in engineering science at a science college of University rank, or an equivalent certificate, will be accepted as evidence of this.

They must give an undertaking that they will attend for at least three academical years, the degree course of study at an University College during the currency of their pupilage, which will extend over a period of six years, including the time spent at college.

Their pay will be that of ordinary apprentices in the corresponding years, plus 4s. per week in years subsequent to their first year's college training. (See Appendix for suggested division of time)

Scheme C.—Youths who, having entered the works as apprentices, succeed during their apprenticeship in passing the matriculation or equivalent examination prescribed under Scheme B, will for the remainder of their time be treated as pupils under Scheme B, in respect of leave to attend college day classes, promotion, and rates of pay. The time served, including that spent at college, will be a minimum of six years.

It is understood that in every case the advancement of an apprentice to pupil rank is at the option of his employer, and subsequent promotion will depend solely upon merit, and the requirements of the business.

In selecting under Scheme C, other things being equal, preference will be given to the sons of workmen and other employés of the firm.

Promotion in general, and admission to the drawing-office in particular, will, at the discretion of the firm, depend upon merit and conduct. This clause refers to Schemes A, B and C.

PREMIUM PUPILS.

In the case of pupils who pay a premium it is recommended that, so far as college training is concerned, they should be asked and encouraged to conform to the regulations under either Schemes A or B, whichever is more suitable to the circumstances of the individual case.

APPENDIX.

The time of pupils under Scheme B may be divided in any of the following ways, according to circumstances:—

1st Alternative.

	Months.
Works	12
College	9
Works	15
College	9
Works	15
College	9
Works	3
Total	72

2nd Alternative.

	Months.
Works	12
College	9
Works	15
College	21*
Works	15
Total	72

3rd Alternative.

	Months.
College	9
Works	15
College	9
Works	15
College	9
Works	15
Total	72

4th Alternative.

	Months.
College	9
Works	15
College	21*
Works	27
Total	72

* Including 3 months' holiday in summer.

SCHEDULE A.

Evening Science and Art Classes.

	Exams. passed. 1st Class Marks.	Exams. passed. 2nd Class Marks.	Exams. not passed but 80% of possible attendance 50% of possible marks for home work.
Board of Education, South Kensington—			
Science subjects—Stage 1	50	30	10
" " " 2	90	50	20
" " " 3	150	80	40
" " Honours	200	120	60
Mathematics—Division I.—Stage 1	50	30	10
" " " 2	90	50	20
" " " 3	150	80	40
" " " 4	150	80	40
" " Honours	250	140	70
" Division II.—Stage 5	150	80	40
" " " 6	150	80	40
" " " 7	200	120	60
" " Honours	300	180	90
Freehand drawing	50	30	10
City and Guilds—			
Science subjects—Preliminary	50	30	10
" Ordinary	90	50	20
" Honours	150	80	40

Armstrong College (Evening Classes)—	I. Division	II.	III.	IV.	
Elementary Stage	60	40	30	20	10
Senior "	140	100	70	40	30
Advanced "	250	200	130	90	50

The Technical College, Sunderland (Evening Classes)—		
General average of attendance, class work, or home exercises and class examinations	Stage 1	50 marks
	" 2	90 "
	" 3	150 "
	Honours	200 "

SCHEDULE B.

Each apprentice gaining 160 total marks and over will be awarded a bonus, calculated according to the scale given below.

All bonuses of 10s. and over will be awarded half in cash and half in suitable books or apparatus chosen by the apprentice, or wholly in suitable books or apparatus if the apprentice so wishes.

BONUS SCALE.

Class marks.—Bonus will be paid at the rate of 20s. per 100 class marks.

Time-keeping and industry (combined).—Bonus will be paid for the combined marks gained for time-keeping and industry in works as per the following scale:—

Apprentices—
Under 17 years of age at 10s. per 100 time-keeping and industry marks.
17 to 18 " 12s. " " "
18 to 19 " 14s. " " "
19 to 20 " 16s. " " "
20 to 21 " 18s. " " "

LAUNCHES AND TRIAL TRIPS.

QUEENSGARTH, steel screw steamer; built by Sir Raylton Dixon and Co.; to the order of the Rea Shipping Company, of Liverpool, Cardiff, and Southampton; dimensions, 283ft. 6in. by 40ft. 3¼in. by 23ft; engines, triple-expansion, 22in., 35in., 59in by 39in. stroke, pressure 180 lb.; constructed by Richardsons, Westgarth and Co.; trial trip, December 15th.

TRINCULO, steel three-deck tank steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Bear Creek Oil and Shipping Company, Limited; dimensions, 396ft. 5in. by 50ft. 6in. by 31ft. 10in.; to carry 6900 tons; engines, triple-expansion, 26in., 43in., 72in. by 48in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, December 18th.

CATALOGUES.

HEWITT AND KELLETT, Bowling Ironworks, Bradford.—A pamphlet dealing with the "Yorkshire" boiler has been sent to us by this firm. It gives extracts from tests and general information relating to this type of boiler.

ED. BENNIS AND CO., Limited.—This is a tasteful little pamphlet dealing with boiler-house economies in drapery and furnishing stores and gives descriptions and illustrations of steam plants in such establishments where "Bennis" stokers are in use.

CROSIER, STEPHENS AND CO., Newcastle-on-Tyne.—This is a little booklet dealing with "Cromil" graphite lubricant. This lubricant is for automobiles, sprockets, sprocket chains, gears, ball bearings, piston-rods, engine and elevator slides, wire ropes, cables, &c.

THE STANHOPE WATER ENGINEERING COMPANY, Limited, 20, Bucklersbury London, E.C.—This is a well got-up pamphlet dealing with water-softeners, purifiers, and filters. The pamphlet gives a good deal of general information on the subject, besides dealing with the company's softeners, purifiers, and filters.

THOS. W. WARD, Limited, Albion Works, Sheffield.—A list of new and second-hand steam boilers has been sent to us by this firm. It deals with boilers of various types and sizes, and the leading dimensions, working pressure, prices, and other important particulars are given in each case.

VEGETAS COMPOUNDS COMPANY, of Gracechurch-street, London, E.C.—This is a little booklet dealing with "Vegetas" boiler fluid for removing and preventing incrustation in steam boilers. It is composed of vegetable substances, which are claimed not to act on iron or other metals, and the use of this fluid is warranted not to injure in any way boiler plates or mountings.

BLACKSTONE AND CO., 81, Cannon-street, London, E.C.—A new catalogue dealing with oil engines has recently been issued by this company. A new feature of the catalogue is that it deals with a number of new sizes of combined oil engines and three-throw pumps. A new marine type of oil engine constitutes another addition. The principle on which the company's engines operate is clearly set forth, and practically everything that the purchaser of an oil engine requires to know is given.

J. B. HAMILTON AND CO., Limited, 110, Cannon-street, E.C.—Two circulars have reached us from this company. They deal with a new pinion for silent driving. It is made from a prepared cotton and is claimed to offer a very high resistance to wear. We are also informed that this pinion enables machines to be run at high speeds without noise owing to the extreme elasticity of the pinion. It is also claimed to be absolutely unaffected by oil.

THE BRITISH, IRISH, AND COLONIAL DEPARTMENT OF THE MASCHINENFABRIK OERLIKON, Oswaldestre House, Norfolk-street, Strand.—Two lists pertaining to squirrel cage induction motors have been received from this firm. One list deals with motors ranging in size from ½ to 8½ horse-power and the other from 12 to 85 horse-power. We have also received two other similar lists dealing with slip ring induction motors. The lists give dimensions, prices, weights, &c.

ADAMSON, RAMSBOTTOM AND CO., Limited, Cleveland Works, Birkenhead.—This is a tasteful little pamphlet dealing with electric and hand cranes of various descriptions Considerable space is devoted to three motor travelling cranes, and the principal parts of these cranes are illustrated separately, and each illustration is accompanied by a brief description. Electric warehouse cranes, derrick cranes and hand-swing cranes are also dealt with, and at the end of the book electric capstans are illustrated and described.

J. H. HOLMES AND CO., Newcastle-on-Tyne.—List No. 106 has reached us from this company. It deals with the motor installations which this firm has fitted in newspaper offices and general printing works, and is a very interesting little publication well got up. Illustrations are given showing the electrically-operated printing machines of many of the large newspaper establishments in London and elsewhere. Switch gear, suitable for this class of work, forms the subject of the latter part of the list.

THE NEW PHONOPHORE TELEPHONE COMPANY, 31, Budge-row, Cannon-street.—A well got up catalogue has been sent to us by this company. It has reference to electric horns for high voltages. These horns can be run on lighting or power circuits of from 50-500 volts. Electric motor horns are also dealt with, which may be operated with 4 volts, and they are made for higher voltages if necessary. In addition the catalogue deals with switches, electric carriage lamps, dry cells, and accumulators.

DAVIES AND METCALFE, Limited, Injector Works, Romiley, near Manchester.—A little booklet to hand from this firm has reference to Metcalfe's patented hot water combination injectors. These injectors are fitted with self-contained steam stop-valve, a delivery stop-valve, back pressure valve, water regulating cock, worming screws, automatic overflow valves and steam regulators. The booklet gives full particulars for working these injectors and some other matter relating to them.

THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY, Limited, Cambridge.—Leaflet No. 61 has been sent to us by this company. It deals with the Weston normal cell, and gives an interesting description, together with other particulars, relating to the behaviour of the cell under various conditions. We are informed that the International Conference on Electrical Units and Standards (1908) have recommended that this type of cell may be conveniently employed as a standard of electric pressure for the measurement of both electro-motive force and current.

JOHNSON AND PHILLIPS, Limited, Charlton, Kent.—Leaflet X to hand from this company deals with voltage transformers for metallic filament lamps. Particulars are given of the iron losses, voltage drop, and the efficiencies of several sizes of transformers of various ratios. Full dimensions and prices are also given. The list also deals with "Osram" lamps, adapters and galleries. We have also received a list dealing with alternators, exciters and regulators, in which prices are given for single, two and three-phase alternators for working at various speeds and voltages. Efficiencies are given for the various machines and weights. Both lists are coded, enabling clients residing abroad to send instructions at the least possible expense.

VAUGHAN AND SON, LIMITED, West Gorton, Manchester.—A highly attractive catalogue devoted to overhead travelling cranes has been issued by this firm. In addition to views of the shops, in which the cranes are built, the book contains sections devoted to electric travelling cranes, platform hand-power travelling cranes, self-sustaining hand-power travelling cranes, pulley block and trolley travelling cranes, the "triple-auto" pulley block, and the overhead switch-trolley runway system. There are some admirable illustrations of an electric trolley hoist, an electric jib crane, electric winch and an electric capstan, and views of works in which Messrs. Vaughan's cranes have been fitted. A word of praise is due to the designer of the cover and end papers, which are very effective.

MAVOR AND COULSON, Limited, 47, King-street, Mile End, Glasgow.—A well got up catalogue has reached us from this company. It deals with generators and motors of the three-phase type. Three-phase alternators direct coupled to high and low-speed steam engines are illustrated, and a full description is given of these machines. Induction motors of the slip-ring and squirrel-cage types are also illustrated and described, and prices, weights and other particulars required by buyers are included. Lastly the catalogue deals with the company's reversible spinner motors, which have been referred to from time to time in these pages. One of the company's motor generators is also illustrated and described.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

The Holidays.

VERY little business has been transacted this week, since the works have been occupied in closing up contract books for the holidays, and few orders are now likely to be given out until the first January market. Considering the end of the year is so near at hand, however, interesting business is kept up fairly well. What new business is being done is concentrated mainly upon pig iron, this raw material being slightly firmer owing to a general improvement in tone and the increasing firmness in the Cleveland market. The placing of orders in America and the continued cheerfulness of the reports from across the Atlantic all tend to excuse—if any excuse should be deemed necessary—optimism in this district. No developments could be reasonably looked for on the eve of the holidays, but there seems to be increased confidence in the prospects for the New Year.

Raw Iron Trade.

It is clear that an unwonted interest is being taken in market developments in the raw iron trade. There have been fitful attempts by consumers to obtain better terms than those current for forward business, but smelters mostly decline to entertain the proposals, and there is no disposition to force iron on the market. Output at the furnaces is kept strictly within bounds, alike as to Midland and Staffordshire brands, and the margin unsold is very small. Smelters hereabouts are gratified at the condition of returning prosperity in the pig iron market on the North-East Coast, and it is satisfactory this week to learn that Cleveland makers quote 9d. per ton more than the prompt rate for delivery over the next year, while 3d. more is asked for January, and 6d. for February and March. Local prices are quoted by makers:—Forge pig iron, Staffordshire common, 46s.; part-mine, 48s. to 49s. 6d.; best all-mine, 80s. to 81s.; cold blast, 110s.; Northamptonshire, 46s. to 47s.; Derbyshire, 48s. 6d. to 49s. 6d.; North Staffordshire, 49s. to 50s.

Manufactured Iron Orders and Prices.

Birmingham Iron Exchange, as this is written, has finished business for 1908, since, although the Exchange will be open on Xmas Eve and also on New Year's Eve, there is certain to be only a scant attendance, and few or no orders will be given out. From the point of view of buying and selling nothing of real interest is occurring. The Galvanised Sheet Manufacturers' Association have met, and, after reviewing the outlook, have reaffirmed the minimum at £12 10s. for 24 gauge corrugated f.o.b. Liverpool. Reports indicated an improvement in business. The spelter market is still stagnant. Values rule nominally at £21 15s. to £21 17s. 6d. The black sheet trade, if it is not still ebbing, is not making any recovery. Quotations rule on the basis of £7 5s. to £7 7s. 6d. for doubles. At this time last year, at the close of 1907, prices of the same class of iron were:—Black iron singles, £8 to £8 5s., doubles £8 2s. 6d. to £8 7s. 6d., and trebles £8 15s. to £9 per ton; so that there has been a reduction during the year just closed of 17s. 6d. to £1 per ton. Galvanised sheets at the end of 1907 were £13 2s. 6d. for 24 w.g. f.o.b. Liverpool—a price 12s. 6d. above that now ruling. The most sensational price change in 1907, it is peculiarly interesting to recall, was a reduction of 15s. per ton on September 12th. This alteration was very significant, and the commonly accepted belief was that it was the outcome of a sudden attack of the American galvanised sheet makers on some of the distant shipping markets. There has been no such price quoted in the year just ended, since the necessity for it has not existed. It has, however, only been avoided by the English makers consenting to buy American steel for making some of their sheets out of it.

Staffordshire Marked Bar Comparisons.

The bar trade presents no new feature. The production of good grade bars is being steadily absorbed, though output has of course shrunk very considerably of late in correspondence with the diminished demand. The standard for marked bars continues at £8. South Staffordshire unmarked bars can be bought at £5 17s. 6d. to £6 5s., according to quality. North Staffordshire crown bars are in fairly good request at £6 10s delivered at ports. It is interesting to recall that the year now closing opened with a drop in marked bars of 10s. per ton, the price being reduced to £8 10s. This class of iron had hovered within a half-soverign range for two or three years previously, the previous adjustments having been as follows:—November 1st, 1905, up 10s. to £8 10s.; January 11th, 1906, up 10s. to £9; July 12th, 1906, down 10s. to £8 10s.; December 7th, 1906, advance 10s. to £9; no change during 1907; January 8th, 1908, down 10s. to £8 10s. The £9 which was twice touched in 1906 was when first declared at the opening of that year, a figure which had not been previously touched for a period of five years. Unmarked bars commenced the past year with a value of £7 2s. 6d. to £7 5s.; hoop iron, £7 15s.; tube strips, £7 5s. to £7 7s. 6d.; and rivet iron, £7 15s. Immediately after the January quarterly meeting unmarked bars lost 2s. 6d. to 5s. per ton of these prices, and rivet iron 5s. to 10s. per ton.

Steel Market.

The structural engineering business still lags heavily in the rear, with the result that finished steel of heavy sections in this district, especially plates, angles, and large bars, are in rather poor demand. But here again there are exceptions, one large establishment in the Black Country having, it is said, booked orders to the end of June. Prices of finished material keep at:—Girder plates, £6 2s. 6d., and boiler plates £7; angles, £5 15s. to £5 17s. 6d.; joists, £5 10s. to £6 5s.; and mild bars, £6 7s 6d. to £6 17s. 6d. Bessemer half-product makers are just able to maintain their price at £4 12s. 6d. to £4 15s., but no more, since they have to be exceedingly wary of the continental imported material. Contracts for bars and billets of native make are unlikely to see further additions until the middle of the New Year, and it cannot be said that sellers look forward with much cheerfulness when they contemplate the probabilities concerning prices.

Steelworks Additions.

A useful steel trade development is the putting down of a new mill by Sir Alfred Hickman, Limited, at its Spring Vale Works, Wolverhampton, for the manufacture of small sizes of finished steel bars. This is a department in which competition with continental houses is very keen, as continental bars are being delivered in the district at 10s. a ton below the local price. The only advantage local makers have had has lain in their ability to give more prompt delivery, and Sir Alfred Hickman, Limited, will now be still further able to meet this competition.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Monday.

Pig Iron during the Year.

THE past year's record must have been an unsatisfactory one for the producers of pig iron. Makers of Lancashire were, however, in an exceptional position, and only offered No. 3 foundry from the middle of February to the end of May, when they with-

drew from the market. Lincolnshire did not maintain the position, opening at 56s. to 57s., and gradually declining to the present figure of 53s. 6d , about which it remains, with a slight upward tendency. Staffordshire and Derbyshire also show a decline of 2s. to 3s. per ton on the twelve months, and as the output of the last-named make has been largely increased during the past few months, it has been pushed for sale, and for quantity considerable concessions have been made to induce business. Small lots, however, have been well maintained in price. It is in Scotch iron—especially Gartsherrie—that the greatest decline in quotations has been registered, and, owing to scarcity, Glengarnock has occasionally been on a parity with it. Eglinton and Dalmellington have also suffered in sympathy. Gartsherrie and Glengarnock opened at 67s., closing at 59s. to 60s. Eglinton and Dalmellington opened at 64s. to 64s. 6d., and closed at 57s. 6d. There was a better feeling at the close than was generally expected, and merchants were asking rather more money. Hematite iron has varied, West Coast opening at 65s. 6d., closing at about 58s., and East Coast 64s., closing at 57s. 6d. Under speculative influences Middlesbrough brands have shown the greatest variation, opening at 57s. 4d. per ton. On several occasions in the first half of the year they reached 60s. and 61s. 4d. For some months it ranged between 58s. and 59s., but closes steady at 58s. to 58s. 4d.

Finished Iron.

Business in this department during the year has scarcely been up to its usual level. Bars remained at £7 10s , closing at £6 10s per ton. Hoops opened at £8 2s. 6d., but for the major part of the year stood at £7 12s. 6d. per ton. Sheets were quoted £8 5s. in July, and ranged from £7 15s. to £8 to the close.

Steel.

Demand on the whole has been fairly good throughout, though towards the end of the year competition made itself felt to some extent. Steel bars opened at £6 17s. 6d. to £7 2s. 6d., and dropped at the end of February about 5s. per ton. In April the figure stood at £6 10s., and in June £6 5s., closing steady at £6 2s. 6d. to £6 5s. Lancashire hoops dropped from £8 to £7 5s. per ton ; and Staffordshire have generally ruled 5s. to 7s. 6d. per ton less than Lancashire. Sheets opened at £8, and closed at £6 17s. 6d to £7 Plates for tank, girder, and bridge work, as also boiler plates, have also seen reduced prices at the close—say, 2s. 6d. to 5s. per ton. English billets have experienced a fair demand, opening at £5 5s. to £5 10s., gradually declining to £4 12s. 6d. to £4 15s. Foreign billets have not been offered in very large quantities comparatively, opening at £4 12s. 6d. and closing at £4 5s. to £4 7s. 6d.

Copper and Brass.

Manufactured closes weak. Sheets have not, as was the case in 1907, seen such enormous prices, when £123 to £124 per ton was asked on spot. In the closing weeks of the same year they had declined to £78 per ton, which was the opening figure of 1908. At the end of January £80 was touched. The lowest figure was £70 at the end of July, and after frequent variations closed at £76 per ton. Copper tubes opened at 9⅝d. per lb , rising to 10d. at the beginning of February. They have been frequently quoted 9d. per lb., but the close is 9¼d. Brass tubes have ranged from 7d. to 8d. per lb., and closed at 7¾d.; condenser opened at 8⅝d., closing at about the same figure. Rolled brass, brass wire, brass turning rods, and yellow metal have each varied somewhat, but remain very little changed at the close.

Sheet Lead.

Has showed some variation. The opening figure was £18 5s., rising to £19 for two weeks in February. The decline since has been gradual, and the closing figures are £16 to £16 5s. per ton.

Tin.

English ingots opened at £122 per ton, and varied almost weekly thereafter. The highest figure was about £144 during the first half of the year. The closing price is about £131 per ton.

The Lancashire Coal Trade.

The coal trade in this county has been by no means as prosperous as in 1907. The average time worked has been about three-quarters to a day per week less, but a slightly larger number of "hands" have been employed. The strike in the cotton trade interfered considerably with the consumption of engine fuel, and slack was a drug on the market. In some cases it was stated that as low as 1s. 6d. and 2s. per ton had been accepted to clear the sidings, which, in some cases, was imperative. House coal closes quiet, but in this, as in other cases, prices show little change on the year. Shipping and bunkering coal has been below the average, and owing to the stiffness in Lancashire prices a number of cargo boats have left the Manchester Ship Canal light to load with coal at South Wales ports. General quotations are :—Best Lancashire coal for domestic purposes, 14s. 2d. to 15s. 8d.; seconds, 12s. 2d. to 13s. 2d.; common, 9s. 2d. to 11s. 2d.; round furnace coal, 11s. to 11s. 6d.; best burgy, 10s. 6d. to 11s. 6d.; best slack, 9s. to 10s.; medium, 8s. 6d. to 8s. 9d.; common, 7s. 6d. to 8s., at the pit. Coal for bunkering purposes, screened, 11s. to 11s. 6d.; unscreened, 10s., delivered Manchester Ship Canal.

BARROW-IN-FURNESS, Wednesday.

Hematites.

There is not the slightest improvement in the hematite iron trade. The demand remains quiet from all sources, and there is no spirit in the inquiry for forward deliveries. Indeed, it is evident there will be no change until the Christmas and New Year's holidays are over, but indications of a change for the better are to be found in several directions. It is believed that the first element of better trade will come from orders for new British warships, and it is probable these will be supplemented with orders of some importance for foreign warships. The usual body of trade in hematite iron comes from the steel industry, and there is no hope of an improvement in this direction until the demand for several of the classes of steel made in this district improves in rails, shipbuilding material merchant sorts, and heavy steel castings. This is most likely to show itself first in a better demand for shipbuilding material. Makers, generally speaking, are short of orders, and there is a disposition in the direction of cheaper price. Mixed Bessemer numbers are at 58s 6d. nominally net f.o.b., and warrant iron sellers quote 57s. 9d net cash, but business is not being done at these figures. There has been an increase in warrant stocks during the week of 1000 tons, and these now bulk at 7500 tons, a low figure ; but it is reported that makers' stocks have also been increased. The chances are that a further reduction of furnaces will be resorted to in order to prevent the increase of stocks. In the special hematite, ferro-manganese, and spiegeleisen trades there is less being done than of late, but it is evident there will be a better trade shortly in ferros and spiegeleisen, as three large cargoes of manganese ore have been imported into the Barrow Docks this week for use at the furnaces in West Cumberland. The demand for native iron ore is quiet, and prices are low at 9s. 9d. per ton net at mines for good ordinary sorts.

Steel.

No improvement can be reported in the steel trade, and the mills in the district are very poorly employed. Orders are coming in very slowly, and it is not expected there will be any change for the better for some time to come. Prices are low, but they do not tempt buyers.

Shipping and Coal.

There is no improvement to note in the shipping trade of the district. Freights are still very low. Coal and coke are in plentiful supply at cheap prices.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Christmas Holidays.

THE work of the year will be practically over by the time this report appears. Very little change has occurred in the general situation since December commenced, and both in the heavy and the light industries it will be too easy to afford somewhat prolonged holidays this season. All firms, of course, are not fixed alike, and the duration of the Christmas stoppage will consequently vary according to circumstances. We hear of cases where it is the intention to re-start on the Tuesday after Christmas ; but these are few and far between, and the resumption will probably apply to certain departments. In a good many instances the closing down will extend from December 24th to the 4th of January. Advantage will be taken of the stoppage for stock-taking and the repairs which may be found necessary. Stock-taking at Christmas is not quite so general in these days as it once was, but the old-established time for such work is observed yet pretty freely, and the overhauling of plant and renovation of shops can be very conveniently carried out at this season.

House Coal Steady.

A steady movement is reported in household fuel, the demand, both from London and the Eastern Counties, having been considerably firmer. While merchants have been ordering supplies more freely to meet the exceptional call customary on the approach of holidays, they are not disposed to entertain any idea of an advance, although the tendency is rather firmer. There are no unduly large stocks at the collieries, and these will be required to compensate for the restricted output caused by the holidays, which, however, are not likely to be so much prolonged in the mining districts. Quotations at pits for the best and secondary sorts remain as before, viz., 11s. 6d. to 12s. 6d. per ton for best, and 10s. to 11s. per ton for secondary descriptions.

Steam and Gas Coal.

Steam coal is somewhat weaker than it was at the time of writing last week, and railway contracts for locomotive fuel are likely to be made more advantageously for the companies than for the coalowners. We mentioned last week that one large company was extending its contracts at considerably lower prices than were current at the beginning of the year. Other companies are negotiating for supplies, and will, no doubt, be able to benefit in a similar way. The shipping trade continues to get smaller, as is customary, of course, at this season of the year. One result of the diminished export business is to increase the quantity available for the home markets, and as there is only a moderate demand for manufacturing purposes the position from the coal-owners' standpoint is made proportionately worse, more particularly as the railway requirements are also somewhat reduced. Probably the latter may be only a temporary condition, and may pass away with the arrangements now in course of settlement. The market for gas coal, both in the South Yorkshire and Derbyshire districts, maintains the firm tone noted last week, the Corporation gas departments and gas companies throughout the country continuing to press for supplies prior to the shutting down of the pits for the usual holidays.

Small Coal and Coke.

The demand for coking fuel and slacks is at present quite equal to the output, which has been diminished by the shorter time worked at the pits. Some increased buying has been recently reported, the purchasers, it is stated, having been wishful to place contracts before the Coal Mines Eight Hours Bill was passed. Last week's prices still hold—small coal, of the description used in the cotton mills of Lancashire, being quoted at 4s. 6d. to 5s. 6d. per ton. Coke continues in good request, best washed at 10s. 6d. to 10s. 9d per ton ; unwashed, 10s. 3d. to 10s. 6d. per ton. The patent coke ovens, it is stated, are not worked to their full capacity owing to a scarcity of coking fuel.

The Iron Market.

The Lincolnshire Ironmasters' Association held a further meeting last Friday, no doubt in view of the approaching holidays. No change, however, was made in the official quotations. We mentioned last week that there had been some improvement in the buying of pig iron. That improvement, we are informed, continues to be maintained. People appear to be leaning towards the conclusion that prices may go up, and are thus inclined to cover their requirements before any such advance takes place. Other considerations, such as the work on the naval contracts and the distribution of specifications from shipbuilders on account of these contracts, will, it is anticipated, help to stiffen the market for raw iron. The general view taken of trade prospects generally is also more hopeful. Hence, no doubt, the tendency to order pig iron which is now more evident. The quotations which have prevailed for some considerable time still hold, viz.: - Hematites, West Coast, 68s. to 70s. per ton ; East Coast, 63s. to 65s. per ton ; Lincolnshire, No. 3 foundry, 49s. per ton ; No. 4 foundry, 48s. per ton ; No. 4 forge, 47s. per ton ; No. 5 forge, mottled and white, 47s. per ton ; basic, 48s. per ton. The Lincolnshire makers still insist upon the premium of 2s. per ton on official quotations. Derbyshire iron is also firmer at former quotations:—No. 3 foundry, 50s. per ton ; No. 4 forge, 49s. per ton.

Bars, Sheets, and Billets.

Business is very languid in bars and finished iron generally. The outlook, so far as can be seen, is not as encouraging as could be desired. Quotations: Bar iron, £6 10s. per ton ; sheets, £8 to £8 10s. per ton ; Bessemer billets, £7 per ton ; Siemens ditto, £7 10s. per ton.

The Heavy Trades.

Some further work has been received in railway material, including rails for the home market. The principal orders in general railway specialities for the year, however, have been from distant markets, mainly from the Indian State Railways and South America. The largest home order was that recently announced as placed by the Midland Railway Company. It was for 50,000 tons of rails, and was placed with three firms in this district. A considerable amount of work is in the market for distant railway companies, and, no doubt, Sheffield will benefit by participating in it when the contracts are placed. We cannot hear of any change in the marine material departments, but there must be some improvement when work recently placed is put actively in hand. It is hoped that other work may follow in the shipbuilding yards, and yield further orders to an important local department which has of late been most inadequately employed. The steel, engineering, and other trades are as previously reported. A satisfactory feature is an improvement in the business done with the United States in steel and other local manufactures.

The Master Cutler on Trade.

The Master Cutler, Mr. Douglas Vickers—of Messrs. Vickers, Sons, and Maxim, Limited—responded to the toast of "The Town and Trade of Sheffield," at a dinner on the 18th inst. The Master Cutler, who was very cordially received, explained at the outset that that was one of the last few days he would spend in this country before making a journey to Japan The task he had before him, in responding to the toast, was not a very happy one, because the town and trade were in a bad state, and at present they had no remedy. It was one of the saddest things we found in our present civilisation, to see large numbers of men out of work, who asked for nothing but work, and who were able to work and would do good work if they could. They could always console themselves that things must come right if they waited, but the waiting was very hard indeed. One of the hopeful signs that he viewed was the lowering of the price of coal. Everybody knew what a menace was the price of coal to the steel trade, the staple industry in the east end of the town, and some relief might come in that direction. What one would like to see was, if it were possible, to arrange something which would prevent bad trade from being quite so bad. The very good trade did not do us the good it might, and the very bad trade did a great deal more harm than it should.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

NOTWITHSTANDING the near approach of the holidays, a good business has been done this week in Cleveland pig iron, and producers are very well situated, for they also booked somewhat large orders last week, there being quite a spurt in buying, it being chiefly consumers who were operating, though some of the speculators likewise thought it high time to cover. A large tonnage of No. 3 Cleveland G.M.B. pig iron was sold at 48s. 6d. per ton for early f.o.b. delivery, but this week the general quotation has been 49s. 3d. for prompt, and 49s. 6d. to 49s. 9d. for next quarter. That people are more sanguine about next year's business is indicated by the fact that some of them have been wanting to buy for delivery over the whole of next year, but producers would not commit themselves so far ahead, particularly when the value of iron is rising and there are indications of improving trade in most branches of the iron and steel industries. Makers, for delivery in the second half of next year, want considerably higher prices than the consumers are prepared to give. This market is further strengthened by more favourable news from Germany and the United States, in both of which countries trade is beginning to show improvement, and the views of commercial men are that the worst of the depression has been experienced. It is reported from Germany that the iron-masters have already sold the bulk of the pig iron which they will make in the first half of the coming year, and there will not be any surplus to be dumped into this country, but, on the contrary, Germany may need even more Cleveland iron than has been sent during the current year. These newly developed features and the spurt which has been in progress since the early part of last week have stiffened our market considerably, and counteracted any unfavourable influence which the poor shipments and rapidly increasing stock might have had. Cleveland No. 3 pig iron has lately been going into Connal's stores at about the rate of 1000 tons per day, and over 120,000 tons are now held, whereas at the commencement of the half-year 47,949 tons only were reported—the smallest stock since 1900. On 21st the price of No. 3 Cleveland G.M.B. pig iron for prompt f.o.b. delivery was 49s. 3d.; No. 1 was at 51s. 3d.; No. 4 foundry at 48s. 3d.; No. 4 forge at 47s. 3d.; and mottled and white at 46s. 9d.; but at least 6d. per ton more had to be given for delivery over the first quarter.

Hematite Pig Iron.

Consumers have bought very little hematite pig iron either this or last month, notwithstanding that there is some improvement in the steel plate and angle trades, but they purchased very heavily in October, and for delivery a good way ahead, and since have been holding off. That is the usual way of doing business in hematite pig iron in such times as these—there is quite a rush of buying for a short time, and then a considerable period when scarcely an order is given out. There is not the steady buying that is noted in connection with some raw materials. Makers do not lack orders, as they sold for delivery well ahead, and there is no pressure to sell. There is not a greater production than satisfies the demand, and no hematite iron is going into stock either with the makers or in Connal's stores ; in fact, no one has had any hematite iron in the latter since April, 1906, and for years only a few hundred tons was stored there. A few second hands, who overbought in October, are still offering small quantities of iron at somewhat less than the producers will accept, but those who buy at these reduced rates must take delivery of the iron at once. From these second hands mixed numbers can be got at 55s. 6d. per ton, but makers hold out for 56s. for prompt and 56s. 6d. for January-February delivery. The latter, however, are in no hurry to commit themselves to deliveries more than a few weeks into next year, as they believe it to be better to wait and take advantage of the higher prices which most people are predicting for next year, and which they seem to have good grounds for expecting as there is undoubtedly more doing in shipbuilding, and most of the hematite iron is used for producing steel for the shipyards. It is not likely that there will be in 1909 the drawbacks from which the shipbuilding industry has suffered during the past twelve months. Rubio ore is in poor request, but there is no great necessity to buy, as consumers are well bought already, and have in some cases good stocks. The price is firm at 15s. 9d. per ton c.i.f. Tees, and sellers will not take less, notwithstanding that there has been a reduction in the rate of freight, 3s. 9d. per ton being taken, Bilbao to Middlesbrough, that being almost the lowest figure ever known.

Manufactured Iron and Steel.

That improvement has taken place in the leading branches of the finished iron and steel trades is pretty generally acknowledged, and inquiries are more numerous than they have been for a long time. Work is fuller at the mills than it has hitherto been this half-year, and the prospects are that it will continue to increase. The rail manufacturers have profited most by the improvement, and have lately shipped large quantities of railway material to India, the Argentine, and Australia. The state of the money market is stimulating enterprise abroad, and the position of producers here is on the whole very hopeful. Heavy steel rails are fairly cheap, for they can be got at £5 10s. net f.o.b., as compared with £6 15s. at the end of June last year, when the boom came practically to an end. It is not likely that anything less than the present price will be reported, but it is probable that the cheapness of rails has, like the cheapness of money, helped forward the revival of railway enterprise abroad. Cast iron chair makers report more inquiry, but the demand has not increased to the same extent as that for rails: £3 10s. net f.o.b. is quoted for them, while for steel sleepers, which are wanted almost solely for export, the price is £6 10s. net.

Shipbuilding.

The shipyards, though better off than they have been hitherto this year, are very far from being well employed. They have had an uncommonly bad year—in fact, the worst since 1886—the lengthy strikes being partly responsible for this, and the tonnages they have launched are not half of what was reported for 1907 ; indeed, some of the firms have not completed more than a third of the work that had to be recorded for 1907. There is altogether a "beggarly array" of launches in this district. It cannot fail to be better next year, though the situation for shipowners is no bettor ; indeed, rates of freight are

even worse than they were, and are the poorest ever known in some trades, notwithstanding that the tonnage laid up is the greatest ever reported. The price of steel ship plates is £6, less 2½ per cent. f.o.t., and iron ship plates are at £6 7s. 6d., less 2½ per cent. f.o.t. Steel ship angles are at £5 12s. 6d., less 2½ per cent., but 27s. 6d. more has to be paid for iron ship angles, there being next to no competition in this branch, as there are only two or three firms producing them; the district, indeed, does not turn out more than about 260 tons per month, while at one time over 11,000 tons per month were made. Like iron plates, they are only wanted for special purposes. It is hoped that it will be possible to keep the plate and angle mills in fuller operation next quarter than has been the case at any time this year. The Moor Works at Stockton have been idle over the whole of this year, and the West Hartlepool Steel Works have not been in operation since last July. Both these establishments are producers of shipbuilding steel.

Coal and Coke.

A better demand is reported, especially on foreign account, and prices have become stiffer. Several good Swedish orders for gas coals have been secured by Durham collieries, including one for 125,000 tons for the Stockholm Gasworks. Best Durham gas coals are quoted at 10s. per ton f.o.b., and best steam at 10s. 9d., with 4s. for ordinary smalls. Bunker coals are easier in price, and the demand is rather quiet—8s. 9d. to 9s. is quoted f.o.b.—and coking coal is 8s. 9d. to 9s. 3d. per ton. A better demand for coke is reported, and the supply of furnace coke is being increased, ovens having been re-started at several collieries. For foundry coke 17s. 6d. per ton f.o.b. is quoted, and furnace coke is at 16s. delivered equal to Middlesbrough.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

Retrospect and Prospect.

THE year now closing has been one of much difficulty to many engaged in the various departments of the iron and steel trades. It opened with a serious want of business in the manufacturing branches, some of the iron and steel works having to be closed down for a considerable period. At no time during the year has there been full employment for furnaces and rolling mills in connection with the finished iron and steel trades. Depression in raw iron would have been more severe had it not been that production was curtailed throughout the year. The makers of special brands of pig iron have done a fair business with English consumers, and also with Italy and the Australian colonies, but otherwise the trade has been unsatisfactory. As regards the future, it may be pointed out that the capacity for production was so much increased in former busy years that it requires no ordinary supply of orders to keep works in operation. It is not expected that the last of the present depression will pass away with the turn of the year. At the same time there are not wanting reasons for encouragement, especially in the considerable amount of shipbuilding work for the British Admiralty that has been placed on the Clyde. Export business also promises some development in South America and elsewhere, and it is hoped that the new year may see an improvement in business generally.

The Pig Iron Market.

A better feeling characterised the pig iron market towards the end of last week. It was admitted that the improved demand for warrants was due to some extent to the anxiety of operators to cover oversales before the holidays, but at the same time there has been a considerable business on the part of home consumers. Reports of probable increased requirements for continental countries have been current, and have had their effect on the market. It is a curious fact that the figure of 49s. 3½d. cash, with which Cleveland warrants closed last week, was also the average price for December last year. The business this week is, of course, curtailed. The warrant market will be closed until Tuesday morning of next week.

Scotch Makers' Pig Iron.

The demand for Scotch makers' pig iron in the last few days has been considerable. One or two fairly large lots are reported to have been placed for delivery over the opening months of the new year. The variations in price are not great, but it is worthy of note that some brands are now quoted 6d. to 1s. better than last week. G.M.B., No. 1, is quoted at Glasgow 55s. 6d.; No. 3, 53s. 6d.; Carnbroe, No. 1, 57s. 6d.; No. 3, 54s. 6d.; Clyde, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Gartsherrie, No. 1, 61s.; No. 3, 56s.; Calder, No. 1, 61s. 6d.; No. 3, 56s. 6d. Summerlee, No. 1, 62s. 6d.; No. 3, 57s. 6d.; Langloan, No. 1, 65s.; No. 3, 60s.; Coltness, No. 1, 90s.; No. 3, 60s.; Glengarnock, at Ardrossan, No. 1, 62s.; No. 3, 58s.; Eglinton, at Ardrossan or Troon, No. 1, 56s.; No. 3, 53s. 6d.; Dalmellington, at Ayr, No. 1, 58s. 6d.; No. 3, 53s. 6d.; Shotts, at Leith, No. 1, 62s.; No. 3, 57s.; Carron, at Grangemouth, No. 1, 63s. 6d.; No. 3, 57s. 6d. per ton.

Pig Iron Shipments.

The past week's shipments of pig iron from Scottish ports were 5356 tons, against 4248 in the corresponding week of last year, showing an increase of 1108 tons. The aggregate shipments for the year to date amount to 294,426, being 79,743 tons less than in the corresponding period of last year. As only one further week's shipments have to be received, the above figures give a pretty accurate idea of the amount of the shipping business during the year. Coastwise shipments of Scotch pigs have shown a considerable improvement in the course of last two or three months. The arrivals at Grangemouth of pig iron from Cleveland and district have been 9851 tons, against 5632 in the corresponding week, showing an increase of 4219 tons, but the aggregate imports show a total decrease till date of 53,096 tons.

Hematite Iron and Steel.

Since last report eight cargoes of hematite ore, all from abroad, reached the Clyde, being three fewer than in the preceding week. No doubt a reduced trade will, as usual, be done until after the turn of the year. The output of hematite pig iron in Scotland has been maintained, and the price is somewhat firmer, merchants quoting 58s. 6d. for delivery at the West of Scotland steel works. Cleveland hematite warrants have been done in our market at 57s. 9d. f.o.b. Cumberland ports for delivery in one month. Business in the steel trade shows little or no improvement. One or two firms indicate that there is some appearance of fair orders for shipbuilding material being put in hand without much further delay. The holidays will be a relief to most steel manufacturers, and it is probable that in some instances the works may be closed longer than usual.

The Finished Iron Trade.

There has been a quiet inquiry for finished iron. Merchants have been doing fairly well as regards the home country trade, the open weather enabling farmers to push on ploughing work earlier than usual, so that the smith trade has been fairly active. In other respects there is hardly anything of a favourable character to report. The export trade is dull, and for the most part unprofitable as far as competitive business with foreign houses is concerned.

The Coal Trade.

The demand for coal has been quieter for home use and shipment. Supplies of all descriptions are full, but there has been hardly any change in prices. It is understood that shipments to Denmark are being kept back at the East Coast ports in order that advantage may be taken of the reduction of the import duty on coal at Danish ports from 1s. to 4d. per ton, which comes into force on 1st January.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

State of the Coal Trade.

THERE was, as anticipated, a good deal of pressure exercised last week to clear, and the total coal despatched at all parts was well up to expectation. At Cardiff the week closed well, with a total day's despatch close to 60,000 tons. At Newport there was a slight falling-off in consequence of delayed tonnage, principally through the weather, but this week is expected to make amends. It was stated on Monday that quite a fleet of overdue steamers would come in during the week. Swansea shipments were well maintained. From Neath and Briton Ferry a fair quantity was sent away, and I note that in one day three large cargoes were sent from the Main Colliery to France.

Coal Prices this Week.

The hardening of prices began in the past week, buyers being unable to secure cargoes except at the figures named by coalowners and middlemen. By the end of the week it was seen that the leading collieries would be well stemmed up to and over the holidays. Prices of best steam coal may be considered as up to 15s. Latest quotations, Cardiff, are 14s. 6d. to 15s.; best seconds, 13s. 6d. to 14s.; ordinary seconds, 13s. 3d. to 13s. 6d.; best drys, 14s. 6d. to 14s. 9d.; ordinary dry, 12s. 9d. to 13s.; best washed nuts, 12s. 6d. to 13s.; seconds, 10s. 6d. to 13s. 6d.; best washed peas, 10s. 9d. to 11s. 6d.; seconds, 9s. 6d. to 9s. 9d.; very best smalls, 8s. 3d. to 8s. 6d.; best ordinaries, 7s. 3d. to 7s. 9d.; inferior sorts, 6s. 6d. to 6s. 9d.; very best Monmouthshire black vein, 13s. 6d. to 13s. 9d.; ordinary Western Valleys, 12s. 9d. to 13s. 3d.; best Eastern Valleys, 12s. to 12s. 6d.; seconds, 11s. 3d. to 11s. 9d.; bituminous coal, very best households, 17s. 6d. to 18s.; best ordinaries, 14s. 6d. to 15s.; No. 3 Rhondda, 17s. 6d. to 18s.; No. 2 Rhondda, 11s. 9d. to 12s.; through, 9s. 3d. to 9s. 6d.; smalls, 7s. to 7s. 6d. Patent fuel, 14s. 3d. to 15s. Coke, 15s. 6d. to 25s., according to quality. Pitwood, 20s. 6d. to 21s.

Newport Prices.

Very best Newport black vein, 13s. 3d. to 13s. 6d.; ordinary Western Valleys, 12s. 6d. to 12s. 9d.; best Eastern Valleys, 11s. 9d. to 12s. 3d.; best house coal, 16s. to 16s. 6d.; patent fuel, 14s. to 14s. 6d.; pitwood, 19s. 6d. to 20s.

Anthracite Coal.

At Swansea, though the week did not close with a large attendance or with much active business, a fair amount was transacted on the week, and it was admitted that conditions were unaltered. Lowest prices:—Best malting, 24s. 6d. to 25s. net; seconds, 22s. to 23s. net; big vein, 21s. 6d. to 22s. 6d., less 2½; red vein, 13s. 6d. to 14s., less 2½; machine-made cobbles, 24s. 6d. to 25s. net; Paris nuts, 25s. 6d. to 26s. net; French nuts, 26s. 6d. to 27s.; German nuts, 25s. 6d. to 26s. net; beans, 17s. 6d. to 18s. 6d. net; peas, 14s. 6d. to 15s. net; fine peas, 10s. to 10s. 6d. net; rubbly culm, 4s. 3d. to 4s. 6d., less 2½; duff, 2s. to 2s. 6d. net. Other coals:—Steam, best, 14s. 6d. to 15s.; bunkers, 10s. to 10s. 6d.; bituminous, No. 3 Rhondda, 16s. 6d. to 17s., all less 2½; patent fuel, 12s. 6d. to 12s. 9d., less 2½.

The Cardiff Chamber of Commerce and the Eight Hours Bill.

As a final effort the Chamber, which, like other influential commercial bodies in Wales, has made strenuous efforts against the measure, wired urgently to Lord Lansdowne on Saturday that in face of the large and important contracts entered into by Wales for 1909, the Bill should be postponed until 1910. Unless some protection be given for the contracts already closed, the results cannot but be disastrous.

The Steel Trade.

A substantial cargo of rails was sent from Cardiff last week to Colomb, totalling 2350 tons. It now seems tolerably certain that the New Year must be advanced a little before the placing of railway orders to any extent. As might be expected, there has been too much work in connection with arrangements and discussions concerning the fusion of large companies to allow of other labour of moment. Rail orders for India are in hand, and colliery needs call for an average supply of light rails. Prices remain, and are regarded as in in all cases bottom figures. A large cargo of steel came to Newport this week from Rotterdam, 1485 tons in one cargo, and a smaller in a second, and 612 tons from Antwerp. Prices not given out this week. Last week Dowlais did a good week's work. This week there will not be much done.

Tin-plate.

It was thought last week, considering the generally satisfactory state of trade throughout the district, that the holidays will be of a very trifling character. Quotations were not given out in time this week from Metal Exchange, Swansea. Trade is good, and makers are well booked with orders.

NOTES FROM GERMANY.

(From our own Correspondent.)

Rheinland-Westphalia.

THE iron market continues in an unsettled condition. Very few orders are coming in, both for raw and for manufactured iron. At a meeting of the Steel Convention on the 17th inst. a moderately good demand was stated to have come in for semi-finished steel, consumers placing their orders for the first quarter of 1909. The business on foreign account is quiet, as before. Trade in rails and in general railway material moves on quietly. In order to prevent a further decrease in employment and to secure regular occupation to the iron industry, the Minister of Public Work is reported to have decided that the requirements of the Prussian State Railways have to be given over to the Steel Convention at once for further distribution among the different shops. There has been an improvement in the sectional iron department, contracts of fair weight being placed now. The demand on foreign account is languid. The depressed condition of prices for bars has caused several Rhenish-Westphalian bar mills to contemplate a union among themselves, and inquiries that have been sent to mills in other districts, especially in Silesia, appear to have been answered satisfactorily. The Steel Convention has now taken the matter in hand, and there is to be a preparatory meeting on the 19th inst. On the whole the bar trade has been a shade more lively quite recently.

List Quotations.

Raw spathose ore, M. 10.90; roasted ditto, M. 15; Nassau red iron ore, M. 11.50 per ton at mines; spiegeleisen, 10 to 12 per cent. quality, M. 78; for sales in 1909, M. 66 to M. 68; white forge pig, Siegerland and Rhenish-Westphalian quality, M. 68; for deliveries in 1909, M. 58 to M. 60; steel iron, M. 70; in 1909, M. 60 to M. 62; basic, free place of consumption, M. 64.80; in 1909, M. 54 to M. 56; Luxemburg forge pig, M. 50.40; in 1909, M. 52 to M. 55; Luxemburg foundry, No. 3, M. 48; in 1909, M. 48; German foundry pig, No. 1, M. 72; in 1909, M. 58 to M. 60; No. 3, M. 69; in 1909, M. 59 to M. 61; merchant bars, common quality, M. 100 to M. 107; iron bars, M. 127.50; iron and steel plates, M. 108 to M. 110; boiler plates, M. 118 to M. 120; sheets, M. 115 to M. 120; drawn wire in iron or steel, M. 127.50, all per ton, free at works.

Export to Baku.

According to a German consular report Westphalian manufacturers find a good market in Baku for hardware, enamelled goods, brass, and cutlery ware. In 1907 import in the above named articles was worth between 500,000 and 600,000 marks. Both prices and the conditions of sale have generally improved during the last few years. North American competition in the articles mentioned has decreased, but Hamburg dealers have been selling for about M. 150,000 tools and locks in the past year.

The German Coal Market.

Changes have not taken place during the week. Silesian coal owners are doing a good business; coke, too, is in animated request. November has been a very dull time for the Rhenish-Westphalian coal trade, and during the present month the depression has continued. The number of working hours is being continually reduced, consumption in engine and house coal being behind production. Stocks in coke are rising; the same is the case with briquettes.

Austria-Hungary.

Nothing worth reporting has taken place on the iron market during this week and the last, but the movement, generally, is downwards in the iron and steel trades. Coal is steady, and firm in price.

Iron and Steel in France.

On the Paris market rather a good business was transacted during the week; quotations, however, remain the same as before. Though nothing definite has been done in the matter yet, the renewing of the Girder Convention is generally considered to be quite certain. German competition being confined to engine coal, there was a good inland trade done in house fuel, and the present quotations are likely to continue till the end of March, while the prices for engine fuel may be reduced before that time.

Depression in Belgium.

Bars and plates are the articles most neglected at present. There is no saying when the falling off in quotations for bars will cease. In the beginning of the present month £4 8s. and £4 10s. f.o.b. Antwerp was quoted. German firms have been offering bars at M. 93 p.t. in Antwerp. Plates are quoted £5 4s. for abroad, and 130f. to 140f. p.t. is the inland quotation. Foreign orders continue to come in rather freely for rails; besides, there have been some large orders secured for the Belgian State Railways, and so the outlook in this branch of business may be considered fair. Quietness prevails in the crude iron industry, but a further decrease in quotations has not taken place, which may be due to the satisfactory prospects regarding the forming of the Luxemburg-Lorraine Pig Iron Convention. Forge pig is quoted 59f. p.t., basic 63f. p.t., and foundry pig 67.50f. p.t. Hardly a week passes without a further reduction in price for some sorts of engine coal; only in house fuel the fairly good condition of previous weeks is maintained. Especially the better qualities are in strong request, while small sorts are comparatively flat.

From the Swedish Iron Market.

During the last months of the year the precarious condition that was noticeable in the Swedish iron industry ever since spring has become more pronounced, and several works have been compelled to limit their working hours. There are only 86 blast furnaces in blow now, while at this time last year 100 were in operation. Also in the bar trade reductions in output have taken place, and export generally has been strongly decreasing. In the first ten months last year 328,100 t. were exported, and only 260,000 t. in the same period of present year. In September of present year only 14,926 t. have been exported, compared with 15,743 t. in the same month last year.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made by the Admiralty:—

Engineer Captain A. J. Nye has been placed on the retired list at his own request.

Engineer Commanders:—C. McK. Norris has been placed on the retired list at his own request, with the rank of Engineer Captain: E. Cornish has been promoted to the rank of Engineer Captain; J. T. H. Ward, to the Victoria and Albert.

Engineer Lieutenants:—H. J. Loveridge and R. Beeman to the Amethyst; A. H. Gorges, to the Sapphire, additional, for the Leven; H. L. Parry, to the Victory, for duty at Portland yard, temporary; G. H. White, to the Blenheim, for the Garry; J. H. Harrison, to the Sapphire, additional, for Kale; and E. F. Briggs, to the Illustrious.

Engineer Sub-Lieutenants:—H. P. Norwood has been promoted to the rank of Lieutenant, with seniority of September 30th, and reappointed, temporary, to the Ocean, in lieu of a Sub-Lieut.; F. H. Hall, to the Triumph; and C. J. Gray, to the Lord Nelson.

PERSONAL AND BUSINESS ANNOUNCEMENTS

MR. E. KILBURN-SCOTT, A.M. Inst. C.E., M.I.E.E., has resigned his position at the University of Sydney to return to London at the end of this year, where he will resume professional work.

MESSRS. D. G. SOMERVILLE AND CO., of 72, Victoria-street, S.W., intimate that they are building large offices for their engineering staff at their works, Archangel Wharf, New Cross, S.E. The Westminster address of the firm will be 116, Victoria-street, S.W. as from December 25th.

WE are informed that Bruce Peebles and Co. Limited, of East Pelton Works, Edinburgh, has been reconstructed, and that its control is now in the hands of an entirely new Board consisting of Messrs. A. W. Tail, M. B. Mountain, C. J. Shiells, Alex. Mackenzie, Chas H. M'Euon and F. G. Andrews. We understand that the business of the company has been conducted without interruption.

MELDRUM BROS., Limited, ask us, as there appears to be an impression abroad that their works are now closed, and as such an impression may prejudicially affect their business, to state that the works have been running all along under the personal supervision of Mr. John W. Meldrum, and that they are prepared to execute any business entrusted to them pending the reconstruction of the company, which they hope may be completed before very long. They request that all communications may be addressed to the works at Timperley

MRS. B. H. THWAITE.—An appeal is being issued by an influential Committee on behalf of Mrs. B. H. Thwaite, who, on the early death of her husband, has been left in very reduced circumstances, in ill health, and with two small children. Mr. Andrew Carnegie has offered to contribute £500 provided a like sum is subscribed by others. There are probably many who when they know the circumstances will be only too willing to lend their aid, and we may say that any pecuniary help will be gladly received by the secretary of the Committee, Mr. William H. Booth, 2, Queen Anne's-gate, Westminster, S.W.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

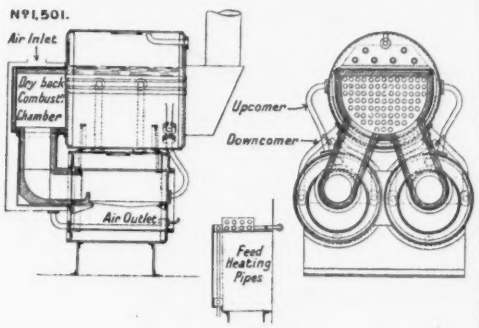
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end o the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM GENERATORS.

1501. January 22nd, 1908 — IMPROVEMENTS IN STEAM GENERATORS, by George Robert Sisterton, of 12, Great James-street, London, W.C.

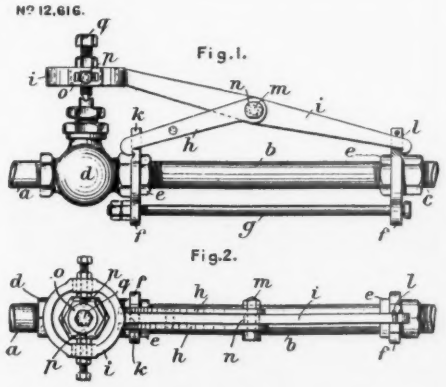
The object of this invention is to enable boilers of the smoke-tube form to be made less in weight than hitherto, and with a water circulation as rapid as in water-tube boilers. No joints are exposed to the action of the fire. The generator consists of three drums, one steam and water drum, fitted with smoke tubes, being placed over two lower water drums, fitted with circular furnaces; an air-cooled dry-back combustion chamber connects the upper



and lower drums at one end, furnishing a passage for the gases of combustion between the drums. Water connections between the upper and lower drums are formed by removable pipes, exterior or partly exterior to the drums. Pipes are also fitted for conducting comparatively cold water from the lower part of the upper drum to the lower parts of the water drums. The combustion chamber is fitted with an exterior air casing furnished with ribs to form passages for air which is delivered to the furnaces; the flow of air may be produced by fans or ejectors. The dry back is fire-brick lined, and removable insulating tubes can be fitted for the purpose of heating the feed water and drying or superheating the steam. A screen of water heating and circulating tubes may also be placed in front of the tube plate.—*November 24th*, 1908.

12,616. June 12th, 1908.—IMPROVEMENTS IN STEAM TRAPS, by Joseph Spencer Lord, of Victoria Engineering Works, Whitfield, and Peter Barlow, County Asylum (annexe), Prestwich.

The engraving, Fig. 1 is an elevation partly in section and Fig. 2 a plan of this invention; *a* is the condensed water discharge and *b* the expansion tube, one end of which is coupled up with the steam pipe *c* from which the condensed water requires drawing off and the other with the discharge valve *d*. To each end of the pipe *b* is secured a flange *f*, the lower ends of which are so tied together by means of a rod *g* as to allow the

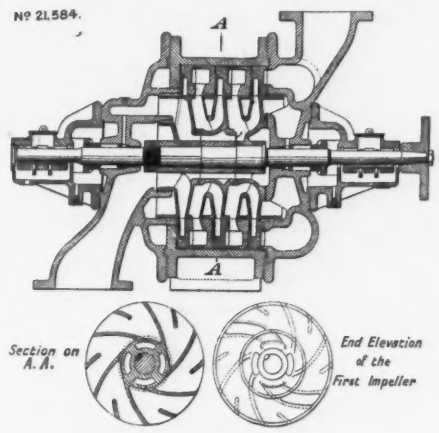


flanges to spread to a predetermined extent. The upper ends of the flanges are adapted to receive a toggle-like system of levers *h i*, the lower ends of the levers being placed in a slot *l* and on a projection *k* respectively, and have each a knife-edge engaging in a V recess in the outside of the flanges *f* respectively. The inner end of the lever *h* by a stud *m* is connected with the lever *i*, which stud is adapted to slide in a slot *n* in the lever *i*. The free end of the lever *i* carries a nut *o* adapted to swivel between two centres *p* rendered horizontally adjustable, and the nut carries a vertically adjustable screw *q* whereby the discharge valve can be made to act more or less quickly according to the pressure of steam in the pipe. The trap operates as follows:—The steam entering the tube *b* causes it to expand, spreading the flanges *f f* slightly apart allowing the free end of the lever *i* to drop and close the discharge valve, thereby preventing the escape of steam. As soon as condensation of steam takes place, the tube *b* cools and contracts, thereby raising its free end of the lever *i* and allowing the discharge valve to open and the condensed water to escape. By adjusting the nuts on the rod *g* the expansion of the tube may be more or less limited —*November 24th*, 1908.

PUMPS AND BLOWING MACHINERY.

21,584.—November 11th, 1907.—IMPROVEMENTS IN OR RELATING TO CENTRIFUGAL PUMPS, by James Thomas Rossiter, of Westlands, Bolton-road, Chiswick.

This invention has reference to those centrifugal pumps in which two or more impellers are mounted upon a common shaft and are surrounded by a casing adapted to place them in series with each other, and in which provision is made for neutralising or balancing the end thrust in the direction of the axis of the impellers, and it has for object to simplify and improve the construction and arrangement of the balancing passage or passages used in such pumps. For this purpose, the balancing passage or passages is or are arranged in the impellers in such a way that the opening to such passage is near the centre of rotation of the impellers and the parts of the impellers around the inlet to such opening, are so arranged that the action of the impeller into which the liquid is being delivered will tend to prevent any heavy matter in the liquid approaching such opening. The balancing passage for supplying water to the balancing pistons or other equivalent working or running parts of a pump may be constituted by an annular passage formed



between inner and outer bosses of the impellers and be separated from one another by longitudinal radial ribs or arms connecting the bosses. This arangement may be modified by making the passage or each passage in the shaft, or in a separate sleeve upon the shaft, or by a combination of some or all of these methods. In order that the rotational balance of the impellers and shaft may not be impaired by such passages, additional passages may be arranged where necessary, symmetrically around the common axis of the impellers.—*November 24th*, 1908.

DYNAMOS AND MOTORS.

17,414. August 19th, 1908.—IMPROVEMENTS IN VENTILATING THE ROTORS OF DYNAMO-ELECTRIC MACHINES, Siemens Brothers' Dynamo Works, of York Mansion, York-street, Westminster, and Otto Kieffer, of 48, Lichfield-road, Stafford.

This invention has reference to the ventilation of the rotors of dynamo-electric machines for facilitating the cooling of the former, and is more particularly useful in its application to the rotors of turbo-alternators. It consists essentially in providing extra longi-

tudinal air passages or holes along the tops of the rotor teeth and in drawing a current of air through the passages by suitable means, whereby the cooling air is directly applied to a part of the rotor where most heat is generated. Referring to the upper engraving, the rotor slots are represented by A and the windings by B, C is a wedge for holding the windings into the slots. The teeth D of the rotor have, according to the invention, holes E punched therein, and on assembling the core plates together in the usual manner, a closed longitudinal passage along the top of each tooth is formed. When the rotors are made solid the air passages E are made by first cutting longitudinal slots in the teeth and then filling up the top portion with wedges. In the lower engraving the air current is indicated by arrows, and it will be observed that it first passes up and in between the winding end connections G, then enters the longitudinal air passages E, passes out between the end connections at the other end of the rotor, and is finally drawn out by the suction action of the fan blades J.—*December 2nd*, 1908.

ELECTRICAL RESISTANCES.

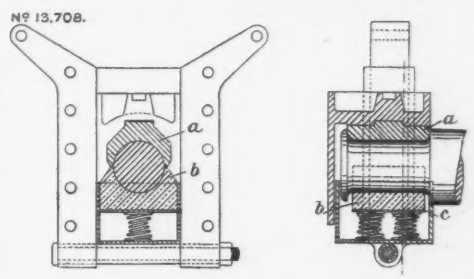
9762. May 5th, 1908. IMPROVEMENTS IN THE MANUFACTURE OF ELECTRICAL RESISTANCES, Charles Ruzicka, of 91, Leighton-gardens, Kensal Rise, Middlesex.

This invention relates to a process for the manufacture and production of electrical resistances applicable for use in electrical heating and cooking apparatus, for the starting and regulating of electric motors, as resistances for use in electrical measuring instruments, and for any other use where an electrical resistance capable of withstanding high temperatures, without any permanent change or damage to its specific resistance or structure is necessary. An electrical resistance body prepared according to this invention consists of either an oxide, or a carbonate, or a chloride, or a nitrate, or a nitrite of at least one metal of each of the following two groups:—The first group comprising—copper, iron and silver; the second group comprising—iridium, nickel, palladium and platinum, or of a mixture, or of a double or multiple salt or combination of such chemical compounds of metals belonging to the two groups, with which is or are mixed one or more either natural or artificial compounds of either silicic or boric acid or of both, such as calcium felspar, silicon borate, or the like, all such compounds possessing a comparatively low melting temperature of less than 1500 deg. Cent., to this mixture is or are added one or more either natural or artificial minerals or stones possessing a comparatively high melting temperature of over 1500 deg. Cent., such as bauxite, aluminium oxide or the like. The proportions in which these substances are employed may be varied within wide limits, by which procedure a great variation of the specific resistance for a given size of resistance body is possible, but taking as an example a resistance-rod having a section of 1 cm. × 1 cm. and the length of 10 cm., which it is to have when finished, the resistance of 300 ohms, the following mixture is given as appropriate:—Iron oxide, 20 parts; nickel oxide, 33 parts; calcium felspar, 26 parts; bauxite, 18 parts. The mixture having been reduced to a state of fine subdivision is thoroughly worked together with the addition of a suitable temporary binding agent, such as arabic gum solution, into a homogeneous mass, from which any desired shape of resistance body may be modelled or moulded, all such modelling or moulding being done under strong pressure. After being dried the body is baked, whilst surrounded by a reducing atmosphere, reducing vapour or a reducing substance, to a sufficiently high temperature to cause on the one hand either a partial or a complete reduction of the metallic constituents, and on the other hand, that the desired degree of vitrification of the body be effected, a hard and compact product resulting. An alternative process is also given, and there are three claims.—*December 2nd*, 1908.

TRAMWAYS AND RAILWAYS.

13,708. June 29th 1908.—IMPROVEMENTS IN CONNECTION WITH THE LUBRICATION OF AXLE OR OTHER SHAFTS, by William Mitford, of 6, Newcomen-terrace, Coatham, Redcar, and Ralph Smarthwaite, of Thorpe Thewles, Durham.

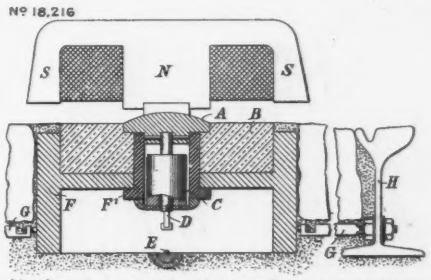
By this invention a solidified lubricant is applied to the underside of the axle, the requisite contact under pressure being maintained by springs. Referring to the engraving accompanying this specification, one is a sectional view through the axle-box as usually provided for railway vehicles, and the other is a corresponding transverse view with parts in section.



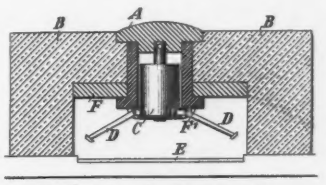
In the illustration, *a* is the keep or bearing of the axle-box, *b* the solidified lubricant mounted on a plate *c* supported by springs within a box which is secured to the frame or structure of the axle-box. In other respects the axle-box may be taken as representing generally the class of axle-box or bearing to which this invention is applicable, modifications being included as required for railway rolling stock or for other purposes in which the axle or other shaft is mounted on wheels and is not supported by an under bearing like an ordinary fly-wheel or other engine shaft.—*November 24th*, 1908.

18,216. August 31st, 1908.—IMPROVEMENTS IN THE SURFACE CONTACT SYSTEM OF ELECTRIC TRACTION, the Suchostawer Patents Syndicate, of 88, Fenchurch-street, E.C., and Henry Mannington Sayers, of 39, Victoria-street, Westminster, S.W.

According to this invention an iron frame is used to form a principal member of the block or structure carrying the contact stud, the frame being of such a formation as to provide two side members, each situated parallel with the track rails and the side members being connected by a horizontal member. In the engravings A is the surface stud of iron, set in a block B of hard insulating material, such as vitrified brick, granite, hard wood, or



Vertical Cross Section through Contact Stud & Pick-Up Magnet



Vertical Longitudinal Section of Stud.

other suitable material, flush with the paving between the rails. C is an iron plunger free to move upwards when attracted by A and by such movement actuating the switch mechanism D, which puts the stud into electrical connection with the line wire E. F is a cast iron frame of H section, in the web of which a circular hole allows the passage of an insulating tube F^1, enclosing the plunger. The block B is contained and supported by F which transmits any pressure on the block to the substructure of the tramway. Lugs formed on the sides of F receive the slotted ends of tie-bars G, the other ends of which are attached by nuts to the rails H. The pick-up magnet on the car is represented by N S. The magnetic flux passes from the pole N to the stud A, the plunger C, the frame F, and back to the divided pole S, so that the air gaps in the magnetic circuit are reduced to the minimum requisite for mechanical clearance, and electrical insulation. Even in the extreme case of the switch chamber being filled with mud or water, the guard ring action of F will prevent the stud being electrically charged to a dangerous pressure. The top edges of the frame F are kept below the paving level, in order that on curves in the line, the collectors depending from N may not come into contact with F, which would result in a short circuit.—*December 2nd*, 1908.

MINES AND METALS.

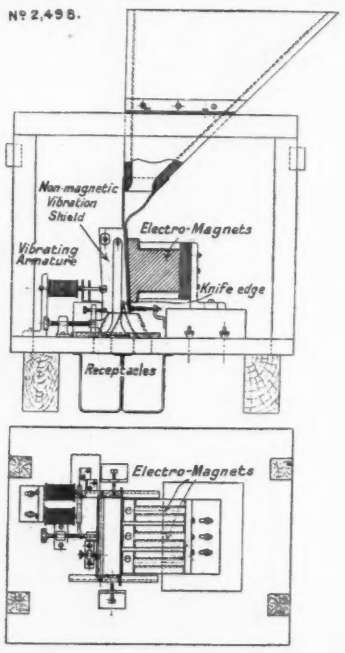
13,699. June 29th, 1908.—*Emanuel Torrini, of 22, Rue de Belleville, Paris.*

This invention relates to a method of or means for converting iron into steel without having to heat the iron to be treated. For this purpose a bath of special composition is provided, into which the article to be treated is plunged in a cold state without any previous heating, and is retained in the bath for any desired time, according to the depth to which it is desired the conversion shall extend. The bath is composed of ferrocyanide of potassium, cyanide of potassium, cryolite, and hydrocyanic acid. The proportions given in the specification may be varied to the extent of about 20 per cent. This bath is heated to a temperature of about 700 deg. Cent. The necessary ingredients must be added from time to time to keep up the strength of the bath to the proportions specified. *November 24th*, 1908.

MISCELLANEOUS.

2498. February 4th, 1908.—IMPROVEMENTS IN MAGNETIC SEPARATORS, by Lawrence Stevens Burt, of Salisbury House, London.

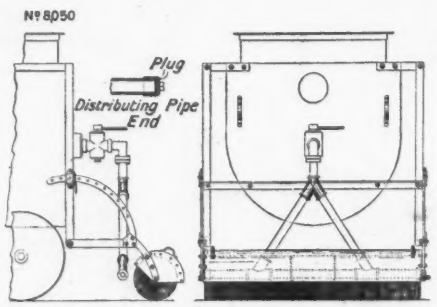
This invention consists in the arrangement of a machine in which the materials to be separated are fed down by gravity through a magnetic field over a surface of non-magnetic material so inclined as to allow the non-magnetic material to drop away from the surface and surrounding magnetic material, the downward feed of the material being maintained by a vibratory movement of the non-magnetic surface. A suitable separating knife edge adjustable as to position is arranged to divide the streams of non-magnetic and magnetic materials for delivery into distinct compartments, the magnetic material being held in the magnetic field



against the vibratory non-magnetic surface until it reaches a point below the level of the dividing knife edge. The invention is clearly shown in the accompanying engraving, where the top view is a plan of the machine, and the bottom view a part sectional elevation of the machine. After the electro-magnets and the electro-magnetic vibrating device have been connected to a source of current and the shield is vibrated thereby, the material to be separated is placed in the hopper and is fed down by gravity on to the shield when all the magnetic material is attracted to and held by the magnetism against the shield, while the non-magnetic material falls to the front side of the knife edge. The vibration of the shield disturbs the equilibrium of the particles held by the magnetism and causes them to travel down the face of the shield under the action of gravity, and continually alters their relative arrangement during their passage so that any non-magnetic particles initially held mechanically by the magnetic particles are freed and fall away into the delivery hopper. The magnetic particles travel down the shield until they get out of the strong magnetic field, when they fall off the lower edge of the shield into the delivery hopper behind the knife edge.—*November 24th*, 1908.

8050. April 11th, 1908.—IMPROVEMENTS IN DISTRIBUTING AND SPREADING APPARATUS FOR DISTRIBUTING TAR OR LIQUIDS ON ROADS, by George Southern, of Hecla Works, Bamber Bridge; Henry Ballans Dewhurst and James Frederick Millington Collins, both of the same address.

This attachment or apparatus is provided with side frames either cast or bent to shape, and adapted to be riveted or bolted to a pitch boiler. Pivoted or jointed to such frames are two brush carriers, and the lower extremities form journals for a cross-axle which carries the brushes for evenly spreading the tar. The brushes are of circular formation, and one continuous brush may be used or separate sections strung on an axle. When at work the brushes revolve as the pitch boiler is drawn along, and the hole in the brush bodies, where a number of sections are used, may in some cases be of larger diameter than the axle, so that the sections can fall independently in case inequalities in a road surface occur. By providing a number of holes a variation in the adjustment can be obtained. Instead of using pins the arms may be set up by using screwed studs, or other arm-shifting appliances to act thereon. When the brush is not required for use it may be elevated and retained in such position by pins or other means. To supply the tar



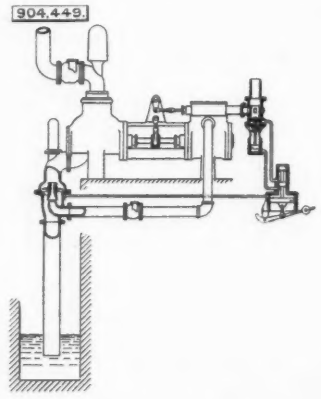
for the brush an inverted Y pipe, which conveys the melted pitch to a horizontal or curved pipe disposed before the brushes—and which pipe has holes or delivery outlets—is attached to the ordinary valved outlet of the pitch boiler.—*December 2nd*, 1908.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

904,449. STEAM-DRIVEN PUMP, *G. Rennerfelt, Scranton, Pa.*—*Filed June 29th*, 1907.

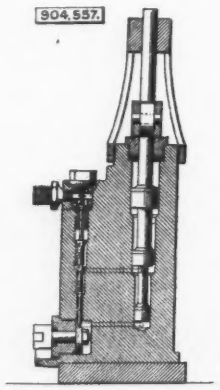
This invention is for the combination of an exhaust steam



ejector with a pump. It is principally intended to get rid of air and to help the suction if the pump is in danger of losing its water. There are no fewer than seventeen claims.

904,557. HYDRAULIC PUMP, *J. W. Nelson, New York, N.Y.*—*Filed February 4th*, 1908.

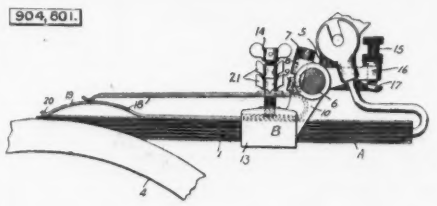
This patent is for a pump, the hydraulic leverage of which is variable. The fourth claim is for a device for generating hydraulic pressure comprising at least three pumps having



common actuating means, a series of downwardly-seating valves, and means for unseating one of said valves and thereby rendering one of the pumps inoperative, said means being further operable to unseat two or more of the valves and render a corresponding number of the pumps inoperative. There are no fewer than thirty claims.

904,801. CURRENT-COLLECTING APPARATUS FOR DYNAMO-ELECTRIC MACHINES, *J. E. Noeggerath, Schenectady, N.Y., assignor to General Electric Company, a Corporation of New York.*—*Filed October 10th*, 1906.

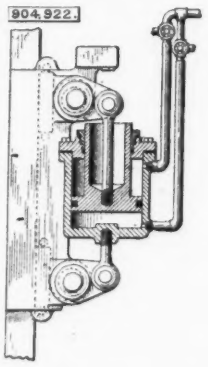
The nature of this invention is well described by the second claim. In a dynamo-electric machine, a collector ring arranged to operate at a high peripheral speed, and a brush engaging said ring, said brush being composed of stiffening pieces and thin strips of material having high conductivity, alternating with thin strips



having low conductivity and greater mechanical strength than the other strips, one of said stiffening pieces being placed on each side of the thin strips and one stiffening piece substantially in the middle of the thin strips. There are five claims.

904,922. CLAMPING MECHANISM FOR PLANING MACHINES, BORING MILLS, AND THE LIKE, *G. H. Benzon, Jr., Philadelphia, Pa., assignor to William Sellers and Co., Incorporated, Philadelphia, Pa., a Corporation of Pennsylvania.*—*Filed June 26th*, 1907.

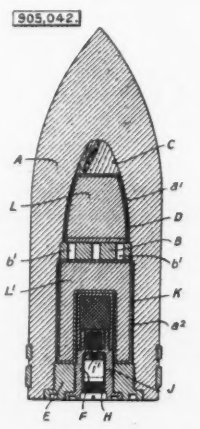
This is one of the hydraulic clamping devices which are now being introduced. The invention consists in the combination with



the cross rail of a wedging, friction, self-locking, clamping mechanism for clamping the cross rail, and fluid-pressure means for operating the wedge-clamping mechanism into locked position, and means to exert fluid pressure in the opposite direction, sufficient to unlock and release the wedge-clamping mechanism. There are seven claims.

905,042. ARMOUR EXPLODING PROJECTILE, *A. Wratzke, Essen-on-the-Ruhr, Germany, assignor to Fried. Krupp Aktiengesellschaft, Essen-on-the-Ruhr, Germany.*—*Filed December 14th*, 1907.

This invention is for delaying the explosion of a shell until it has got through the armour plate. The claims are for an armour-piercing projectile having a hollowed tapering point, and a burst-



ing charge arranged in the hollow space; a solid body arranged in the reduced end of the hollow space and having an abutting surface against which lies the bursting charge, this abutting surface being of an area sufficient to prevent ignition of the bursting charge by the concussion caused by the projectile hitting the armour; a fuse adapted to be ignited by longitudinal displacement at the instant of impact; and means separating the fuse from the charge, whereby the transmission of fire from the fuse to the bursting charge is delayed. There are three long claims.

END OF VOL. CVI.

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PROFESSORSHIP IN MECHANICAL ENGINEERING.

The Norwegian Government (Church and Educational Department) DESIRE to APPOINT a PROFESSOR in MECHANICAL ENGINEERING for the Tekniske Hoiskole (Polytechnic Institute) at Trondhjem, Norway.
The Polytechnic Institute will probably be opened after the summer of 1910, but the appointment may date from the beginning of 1909, the Professor meanwhile assisting in laying out plans for the Engineering Laboratory and such other preparatory arrangements as he may be able to undertake.
As it is conceivable that some time may elapse after the opening of the Polytechnic Institute before a sufficient number of students will have attained such proficiency as to occupy the Professor to the customary extent in his special subjects, it is assumed that the Professor would temporarily take over instruction in such kindred subjects as he may be qualified to undertake to make up the time usually given by a Professor, say, 8 or 10 lectures weekly, besides exercises.
The Professor will be required to contribute to the Widows Pension and other Pension Fund (if any), and to submit to such alterations in the scheme here of the Professorship as the Legislature and Crown may enact.
The salary offered commences with Kr. 4500, rising to Kr. 6000 by three additions of Kr. 500 each per annum after 5, 10, and 15 years. The Government are, however, authorised, if necessary, to grant some or even the whole of the additions at an earlier period. Candidates should therefore state what they would be willing to accept. It should be observed that the Professor is not debarred from undertaking other work compatible with his duties.
Should any candidate be unable to accept immediate appointment, he should state at what time he could do so, and how far he would be willing and able to assist previously and for suitable remuneration as above-mentioned with the plans.
The Professor must be sufficiently acquainted with the Norwegian language.
The form of application is "To the King," and should be addressed to "Den norske Regiering Kirke-og Undervisningsdepartement, Kristiania," before the end of January, 1909. 709

City of London Union.—The Guardians of the above Union have for SALE two Galloway type LANCASHIRE STEAM BOILERS, each 30ft. long by 8ft. diameter, built by Galloways, Ltd., Manchester, in 1899, for a working pressure of 160 lb. per sq. in., complete with all fittings and mountings, including a Hotchkiss circulator. These have been used alternately from 1899 until 1908.
They can be inspected between the hours of 10 a.m. and 4 p.m. on application to the Clerk of the Works at the City of London Union, Clifden-road, Hackney, N.E., on production of business card.
TENDERS for PURCHASE are desired, which must include the cost of removal of the boilers and cartage from the site.
The brickwork setting will be removed by the Guardians.
Tenders should be addressed to the undersigned by Saturday, 9th January, 1909.
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Clerk.
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Commonwealth of Australia.— The Commonwealth Representative is prepared to receive TENDERS for the SUPPLY and DELIVERY on the Wharf at Sydney, New South Wales, of a complete PLANT of MACHINERY for MANUFACTURING SMALL ARMS, BAYONETS and SCABBARDS.
Forms of Tender, specification, and general conditions may be obtained on application at the Commonwealth Offices.
Tenders, made out on the forms supplied, must be delivered under sealed cover, endorsed "Tender for Plant, Small Arms Factory," to the undersigned not later than 11 a.m. on Monday, January 18th, 1909.
The lowest or any Tender will not necessarily be accepted.
R. MUIRHEAD COLLINS,
Commonwealth Representative.
72, Victoria-street,
Westminster, London, S.W. 378

Midland Railway. — Northern COUNTIES COMMITTEE (IRELAND).
TENDERS FOR FISH-PLATES, &c.
The Committee are desirous of receiving TENDERS from Manufacturers and others for the SUPPLY and DELIVERY in the Permanent Way Yard, Duncrue-street, Belfast, of (A) FISH-PLATES and (B) BOTTOM PLATES, viz.:—
(A) 32 Tons of Section 40, weight per pair 14 lb. to 16 lb. (approx.), cut to specified lengths.
50 Tons of Section 43, weight per pair 18 lb. (approx.).
50 " " 46, 15½ lb.
and alternatively for half of each of above quantities, with, in addition,
150 Tons of Section 55, weight per pair 50 lb. (approx.).
(B) 25 Tons of 6in. by 8in. Plates.
25 " 9in. by 7in.
and alternatively for half of each of above quantities.
The Fish-plates to be of steel complying with the B.S. specification for steel rails. The Bottom Plates to be of steel complying with B.S. specification for structural steel. Name of process by which steel is proposed to be manufactured to be stated in Tender. The whole to be of British manufacture throughout. Copies of the drawings (A and B) and forms of Tender can be obtained from the undersigned. Proposals to be sent in sealed envelope, endorsed "Tender for Fish-plates, &c.," and addressed to the Chairman of Committee at Belfast, so as to be with him on or before Tuesday, 26th January, 1909.
JAMES COWIE,
Secretary of Committee.
York-road Terminus,
Belfast,
21st December, 1908. 733

POWER STATION PLANT FOR SALE.

The Hull Corporation are Prepared to receive OFFERS for the following PLANT, which has been removed to make room for other plant, viz.:—
One Babcock and Wilcox Boiler, evaporative power about 3000 lbs. per hour, with mountings complete, except vertical tubes, which have been cut.
One Compound-wound 300 K.W. Tramway Generator, 550 amps., 550 volts, 360 r.p.m., with coupling for direct drive.
One 8in. Centrifugal Pump, capacity 1000 gallons per minute at 450 rev.
One 3-Throw Geared Feed Pump, capacity 1500 gallons per hour.
Further particulars may be obtained of the CITY ENGINEER, Hull, or of the TRAMWAYS ELECTRICAL ENGINEER, Alfred Gelder-street, Hull.
No special form of Tender is required. 701

TO SHIPBUILDERS, MANUFACTURERS, AND OTHERS.

The Mersey Docks and Harbour Board are prepared to receive OFFERS to RENT certain portions of their LAND, with extensive water frontage, and forming eligible sites for shipbuilding, or the erection of manufacturing, engineering, or other works thereon.
Further particulars can be obtained on application to the undersigned.
MILES KIRK BURTON,
General Manager and Secretary
Dock Office, Liverpool. 517

South Indian Railway.—Electrical ENGINEER.
The South Indian Railway REQUIRES the SERVICES of a fully qualified ELECTRICAL ENGINEER to Take Charge of the Electric Lighting of Trains and the Installation of Electric Driving in the Company's Locomotive Shops.
Candidates, who may be between the ages of 25 and 35, must, in addition to electrical knowledge, have had a mechanical training. They must have had practical experience of electrical train lighting and the application of electricity to the driving of workshop machinery.
The salary will commence at the rate of Rs. 500 per mensem, and rise by annual increments of Rs. 50 to Rs. 700 per mensem.
The engagement is to be for 5 years, and the passage to India will be paid by the Company.
Applications, in writing only, to be addressed to Mr. Robert White, Consulting Engineer to the South Indian Railway Company, 3, Victoria-street, Westminster, S.W.
By order,
V. E. DE BROË,
Secretary.
727

The Institution of Electrical ENGINEERS.
The Council is prepared to consider APPLICATIONS for the APPOINTMENT of SECRETARY of the INSTITUTION from candidates of good standing only and of not more than 45 years of age.
In making the selection importance will be attached to the following qualifications:—
Administrative experience.
Tact and business capacity.
Acquaintance with the profession.
Knowledge of modern languages.
Technical knowledge.
Applications, stating salary required and addressed to "The PRESIDENT of the INSTITUTION of ELECTRICAL ENGINEERS, 92, Victoria-street, London, S.W.," must be delivered on or before Tuesday, January 12th, 1909. 694

Wanted, an Engineer, of Good education and sound technical training, experienced in the Designing of Machinery and Preparation of Working Drawings for the shops. A knowledge of German and works experience advantageous.—Address, with full confidential information, to HENRY SIMON, Ld., Flour Mill Engineers, Box 405, Manchester. 696

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The Proprietor of the Patent No. 1573 of 1906, for "Improvements relating to the Manufacture of SAFETY EXPLOSIVES," is DESIROUS of ENTERING into ARRANGEMENTS by way of LICENCE and otherwise on reasonable terms for the purpose of EXPLOITING the same and ensuring its full development and practical working in this country.
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„	9	„	18	„	×	12	„
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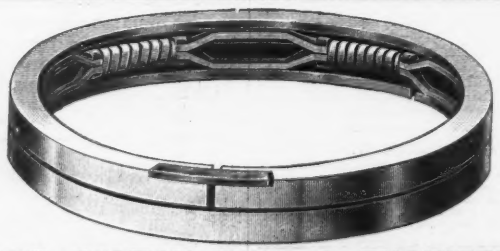

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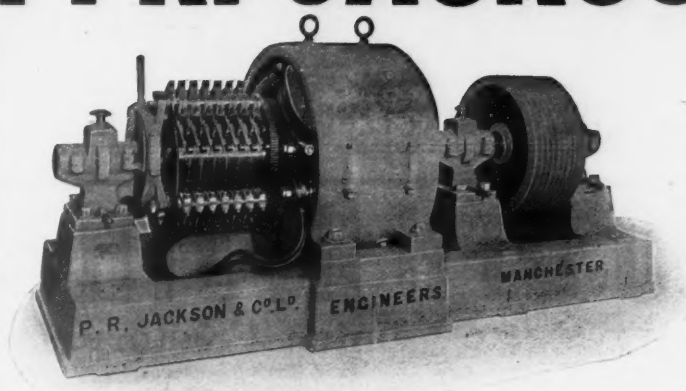

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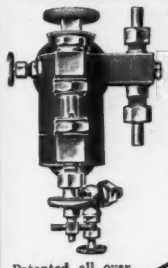

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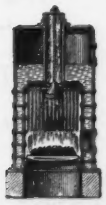

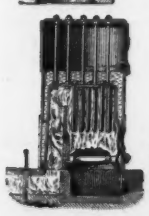

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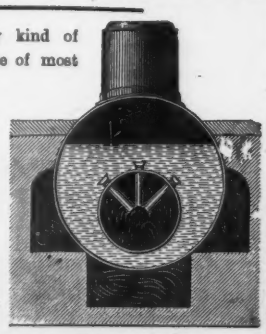

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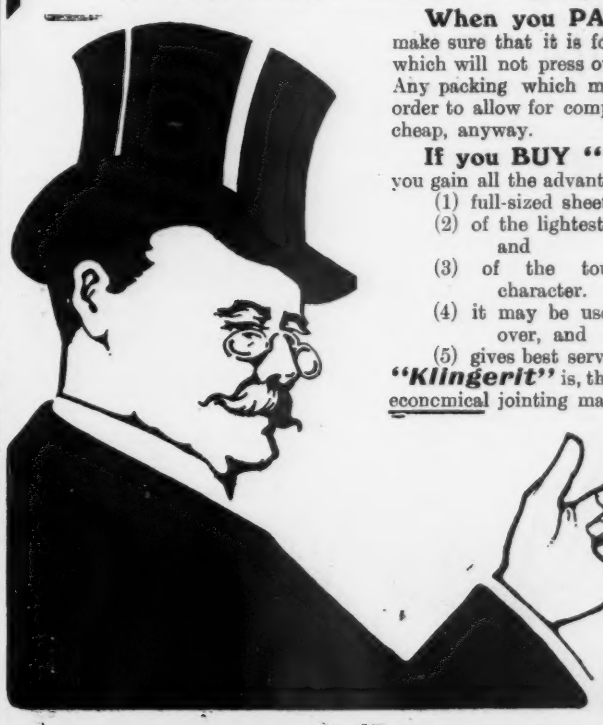

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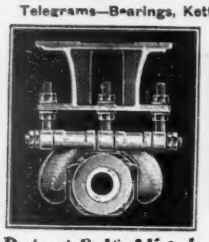

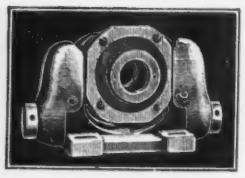

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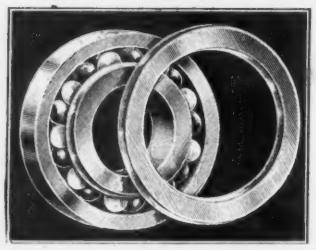

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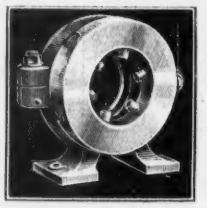

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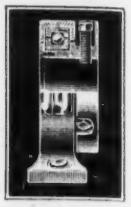

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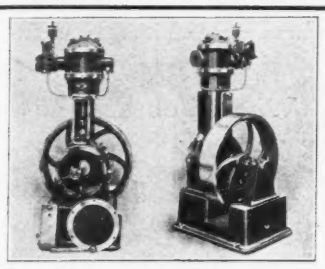

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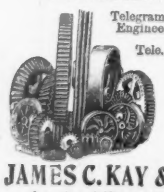

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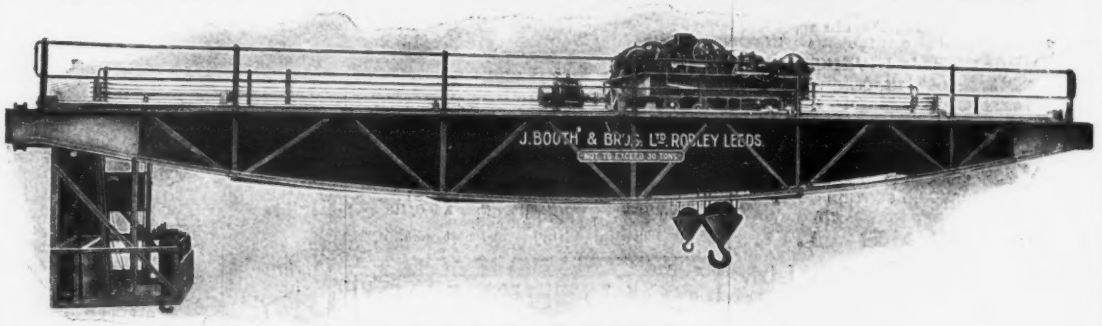

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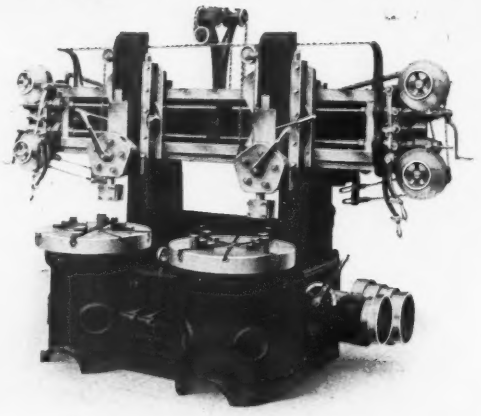

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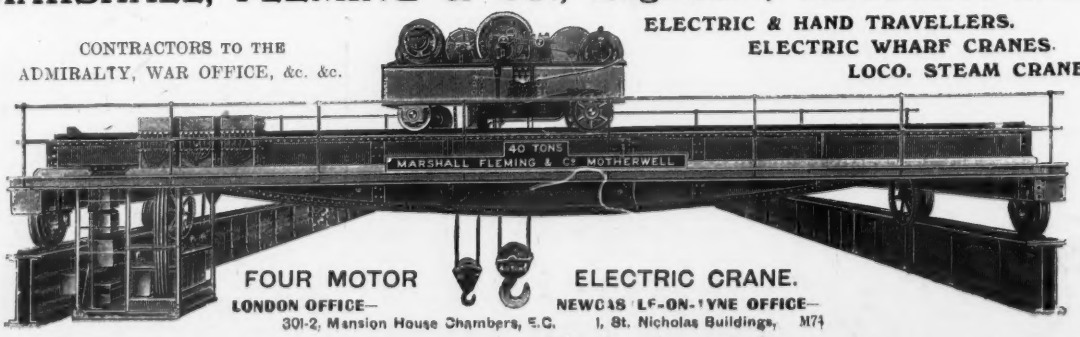

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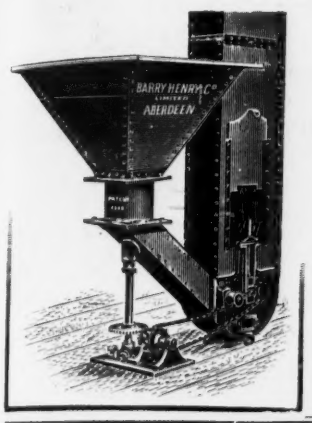

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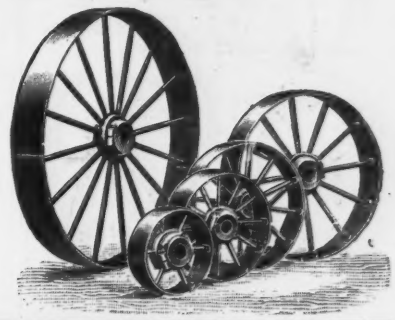

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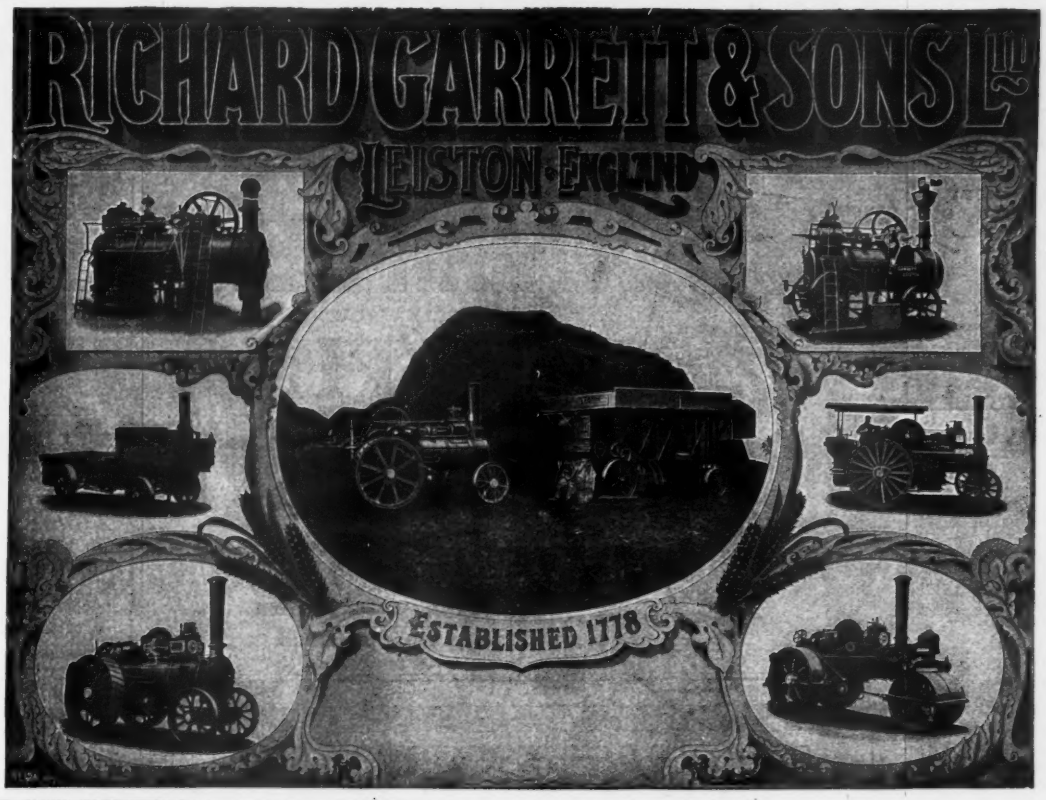

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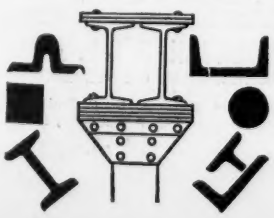

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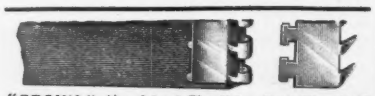

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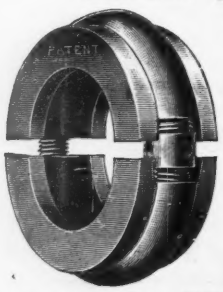

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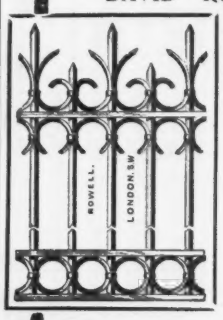

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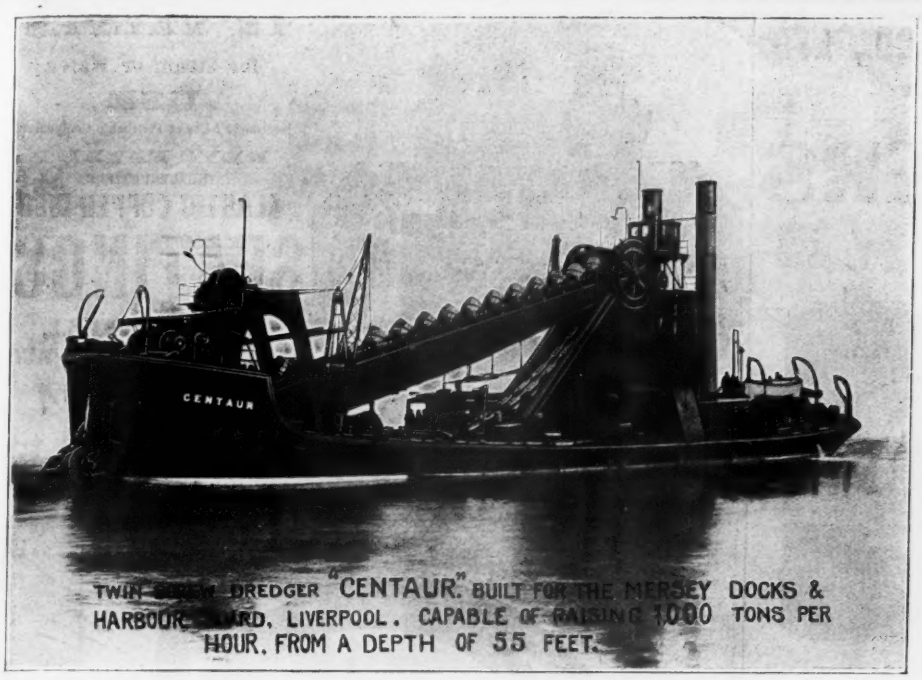

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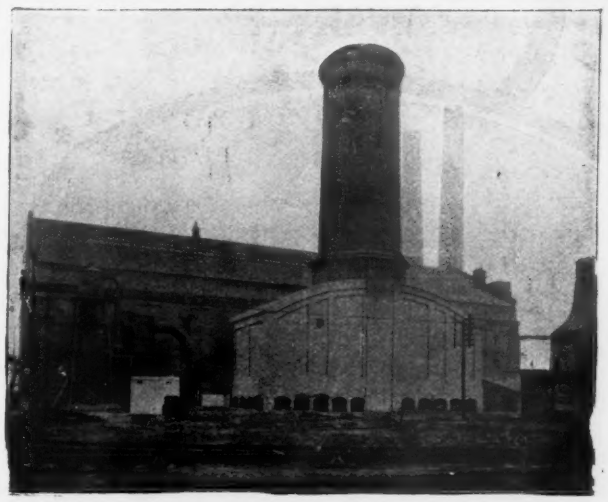

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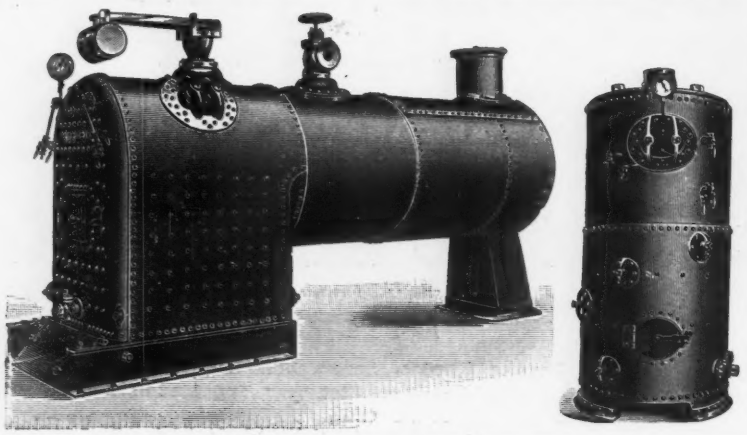

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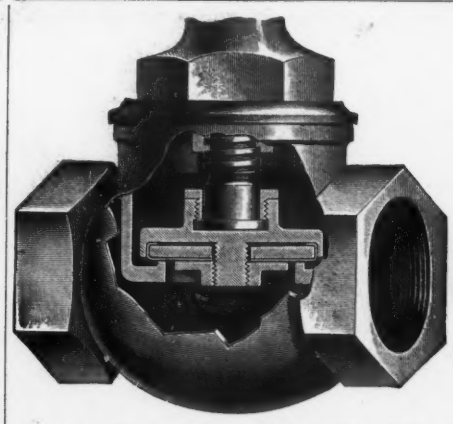

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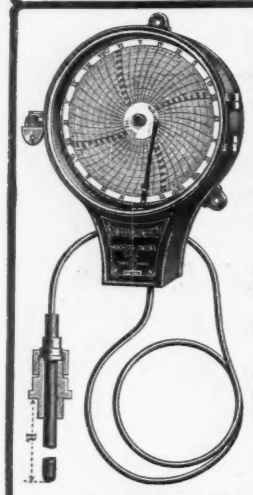

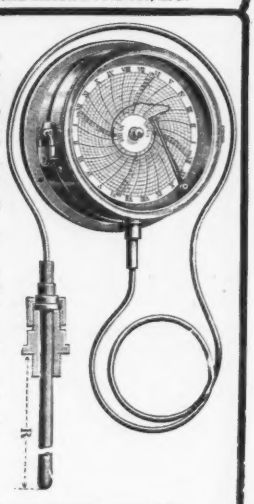

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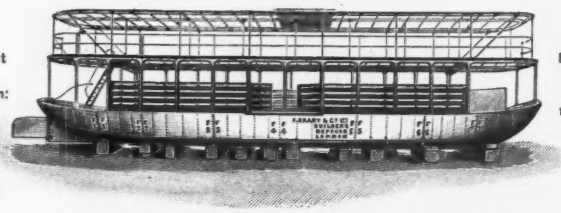

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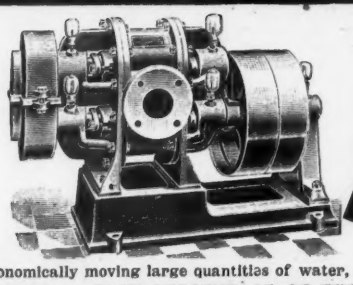

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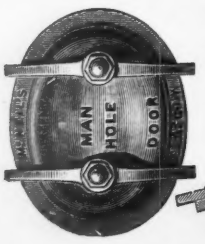

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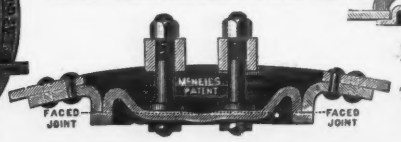

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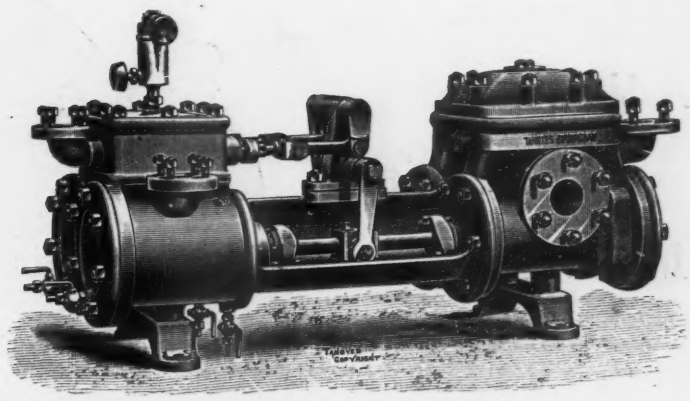

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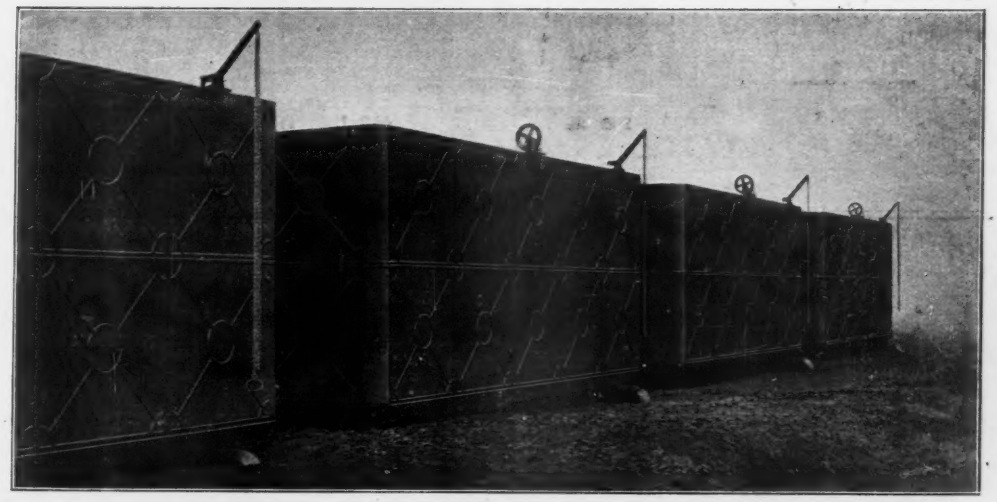

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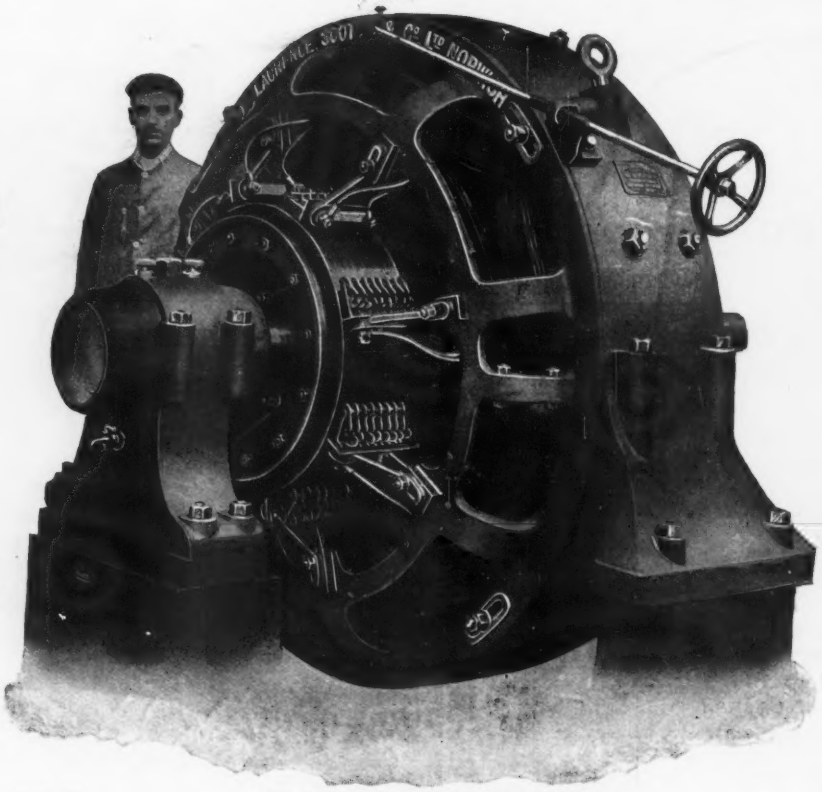

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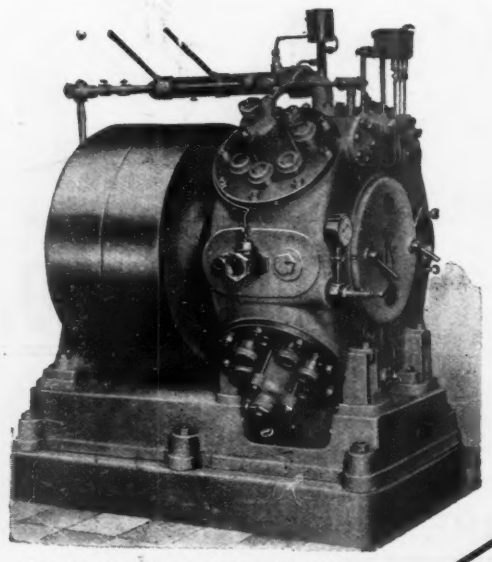

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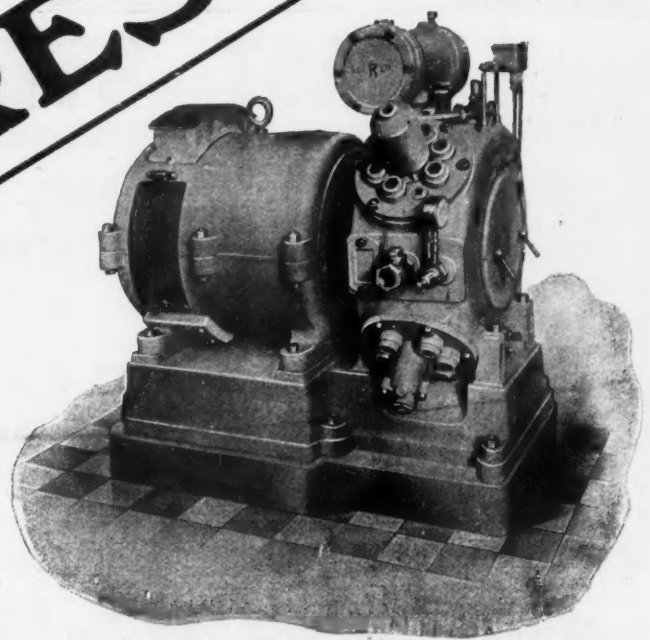

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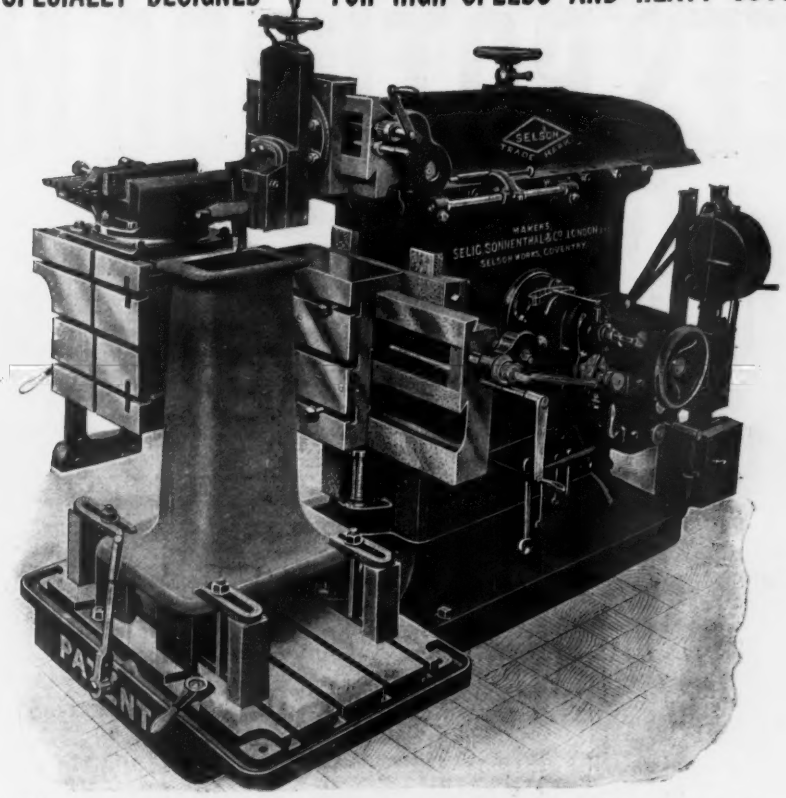

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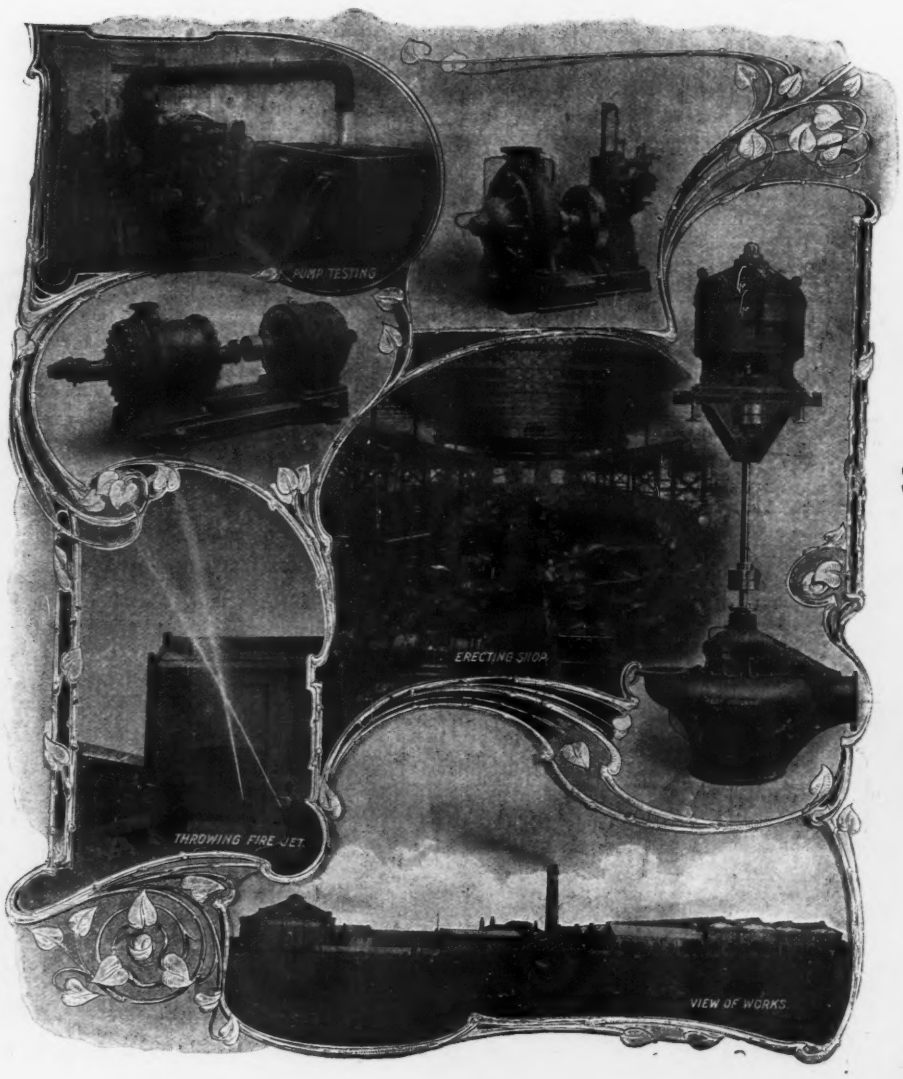

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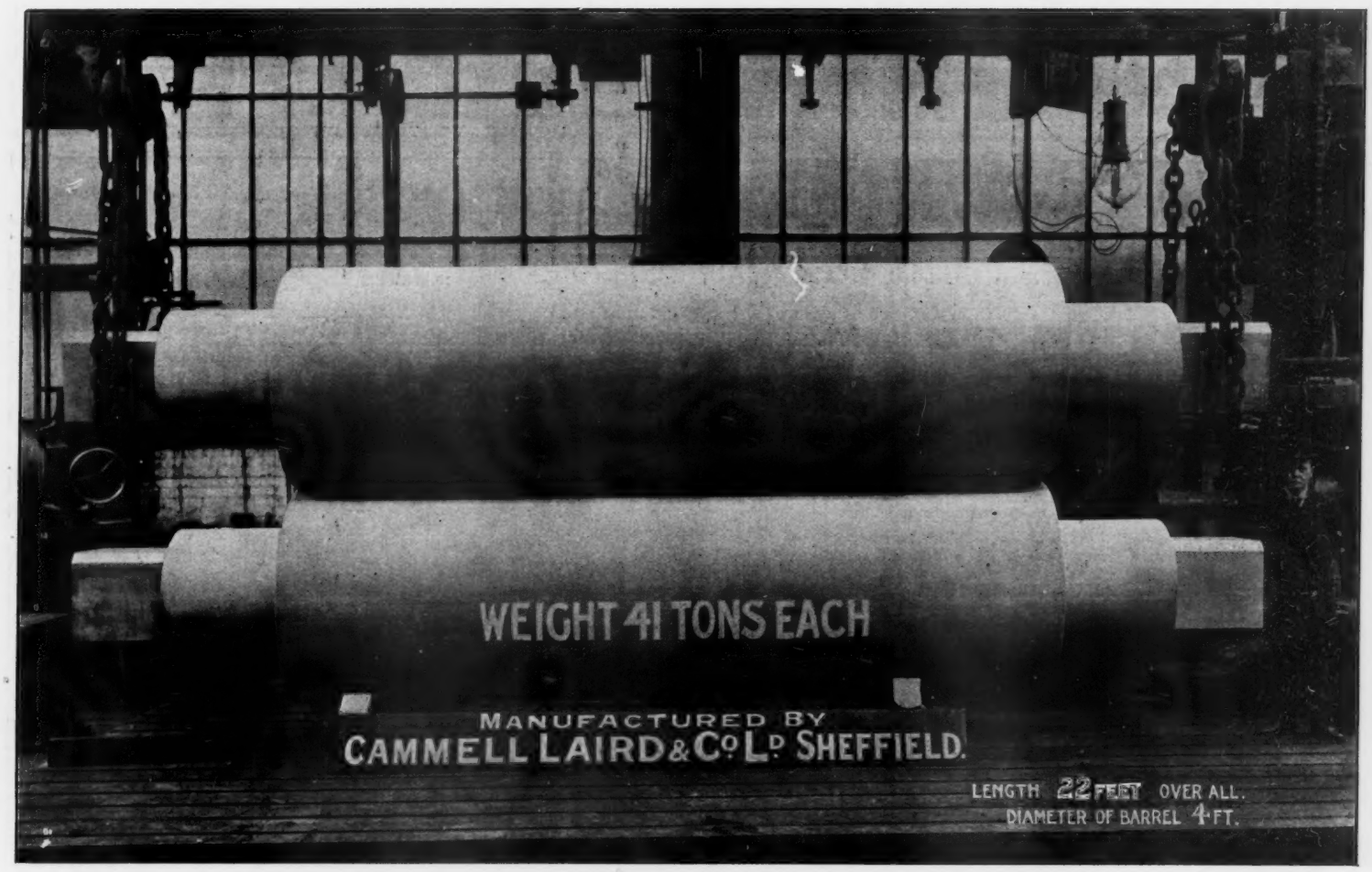

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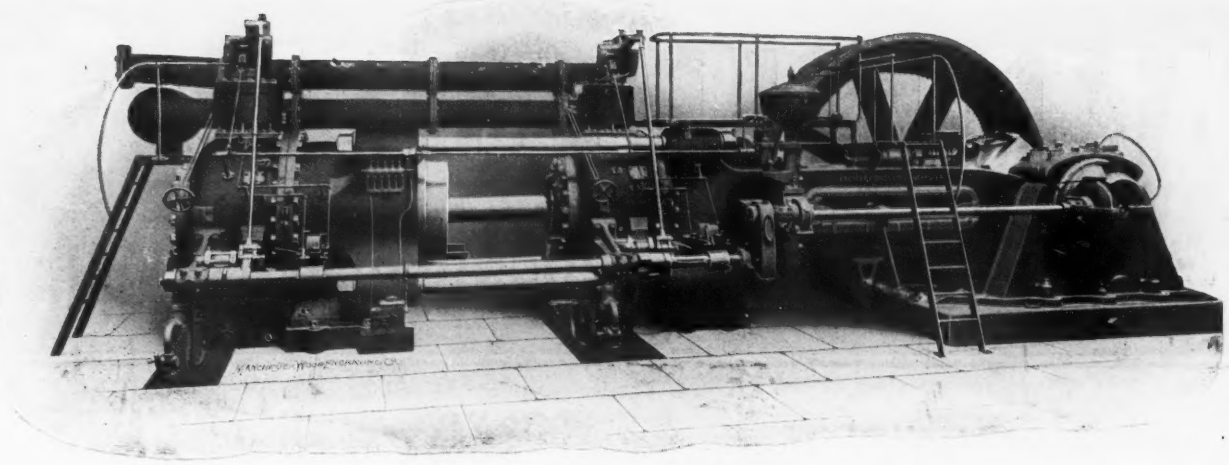

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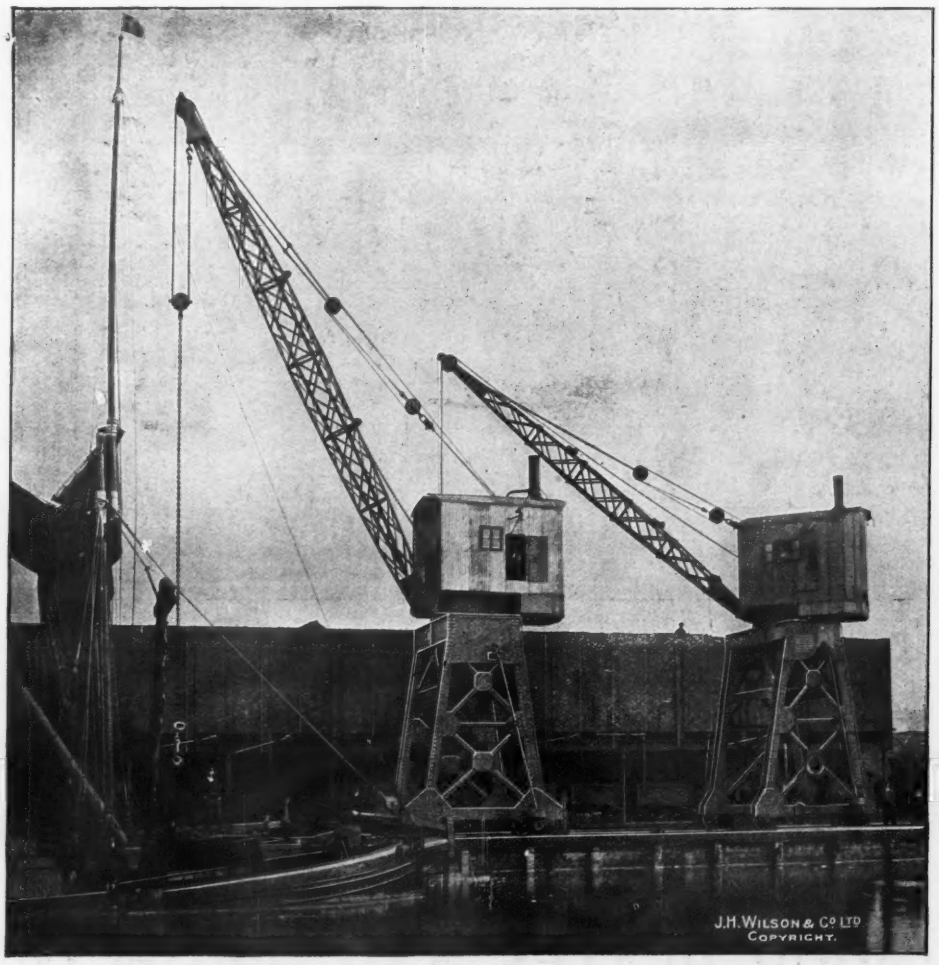

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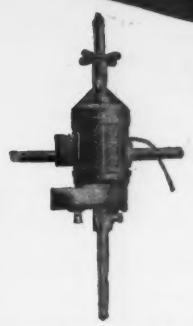

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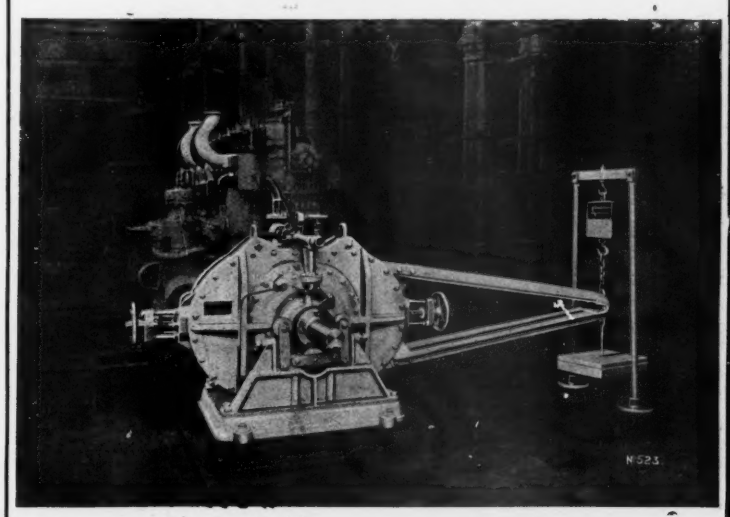

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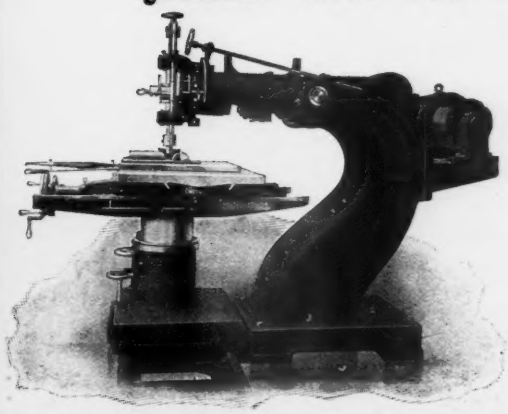

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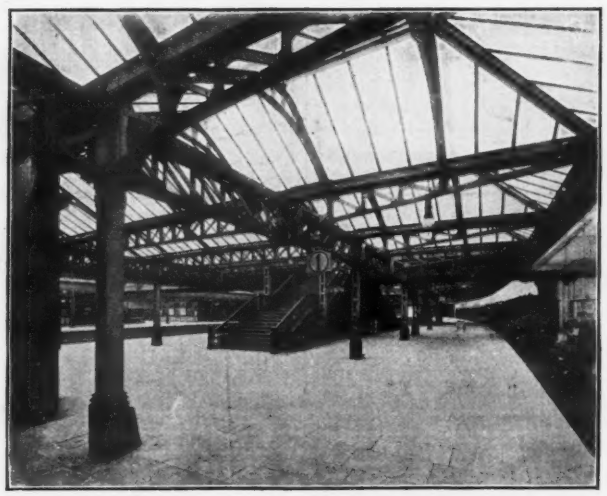

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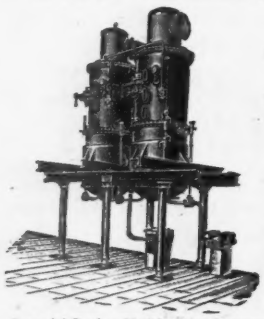

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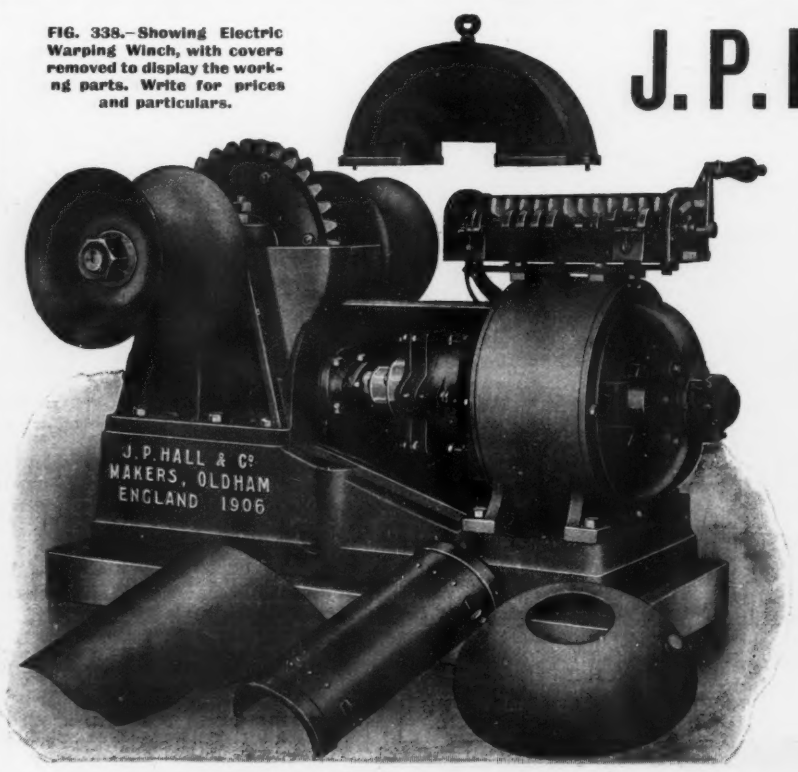

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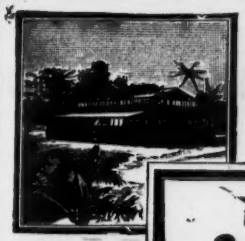

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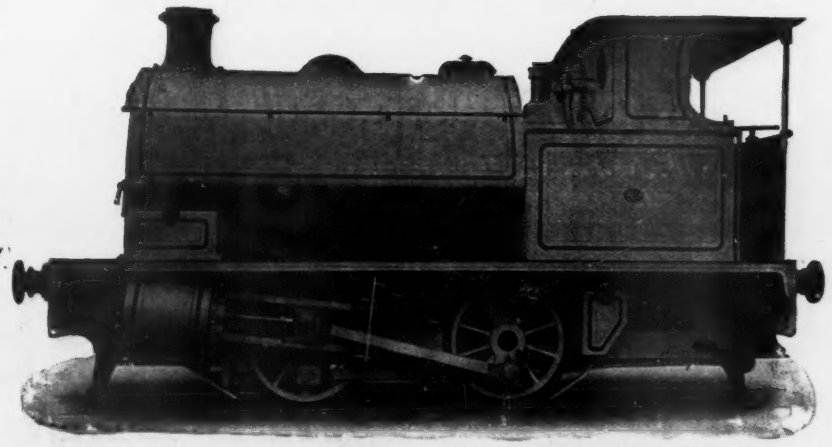

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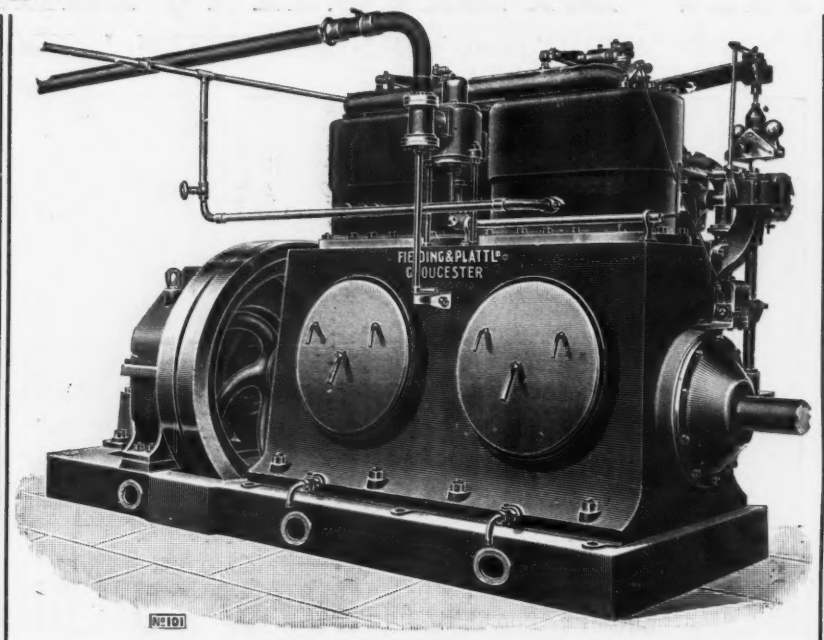

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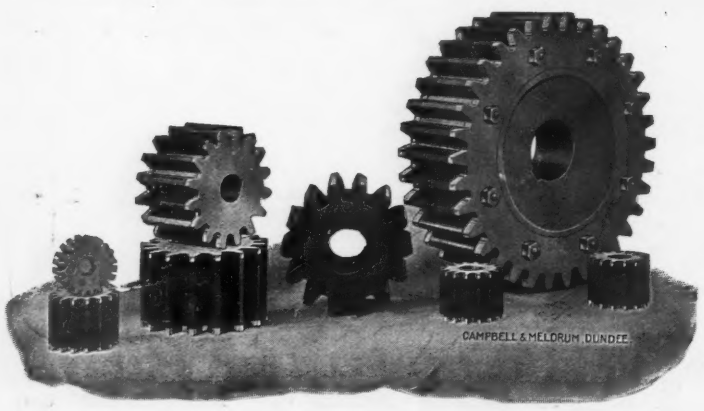

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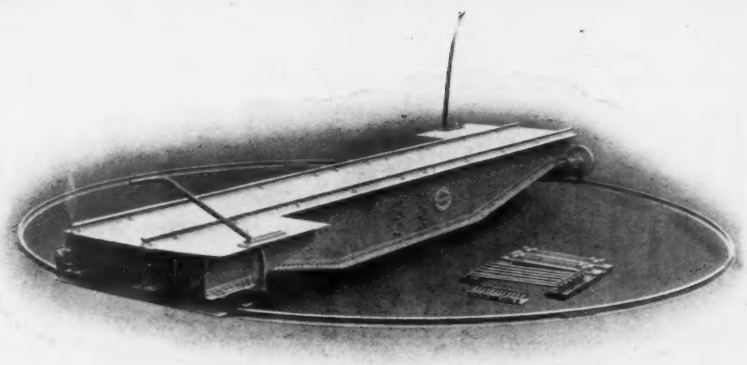

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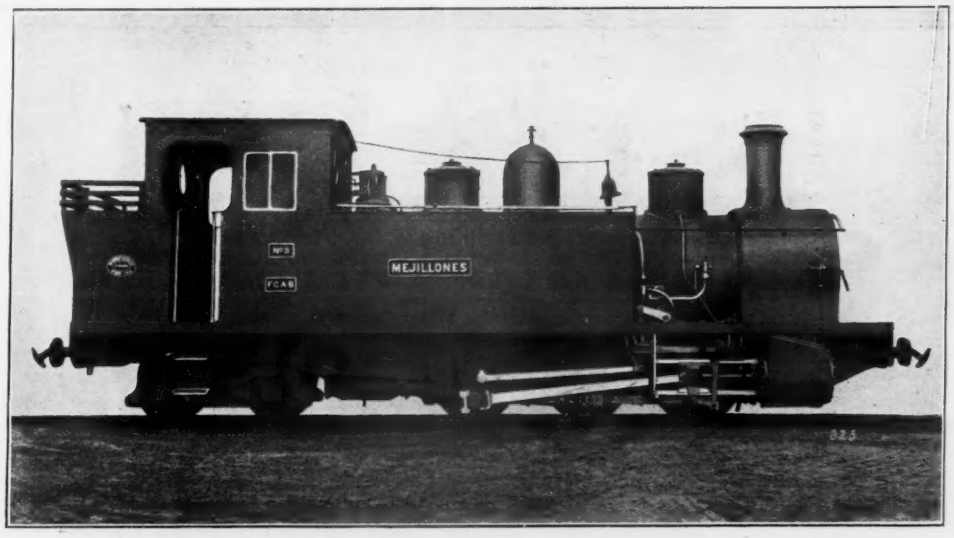

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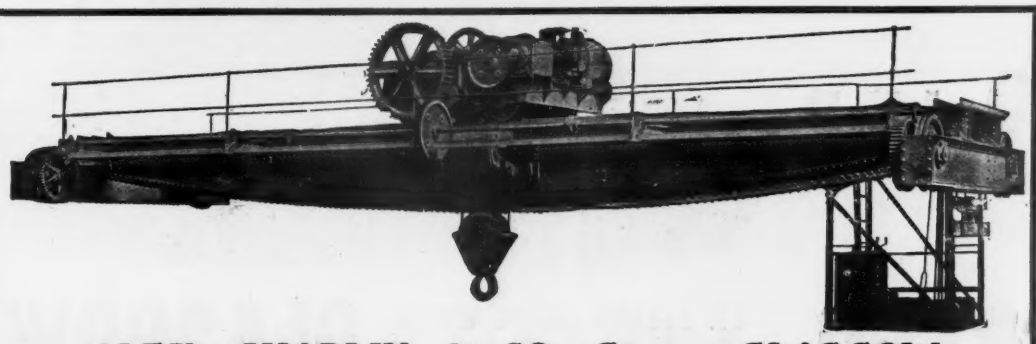

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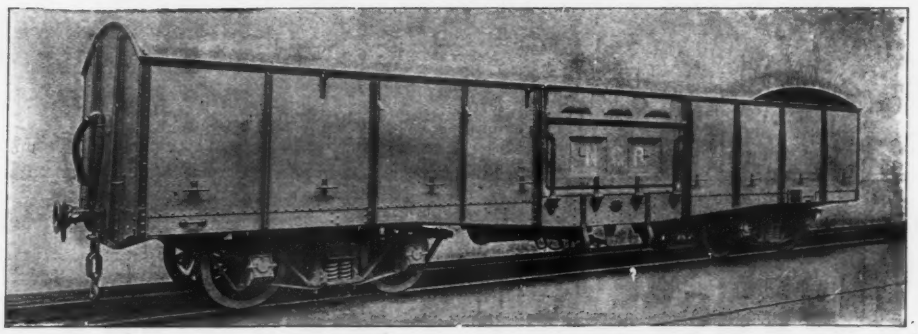

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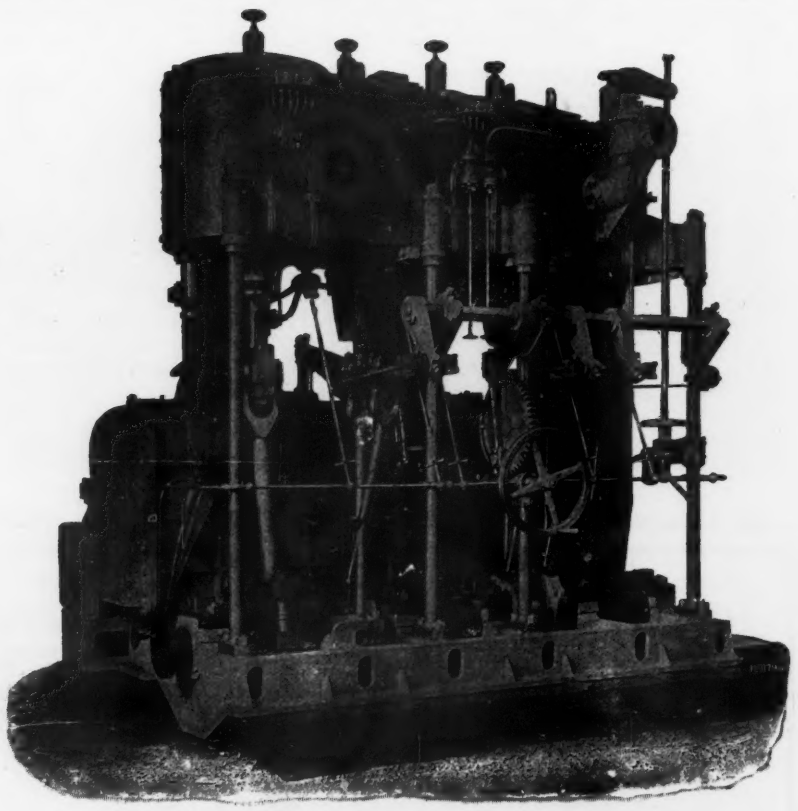

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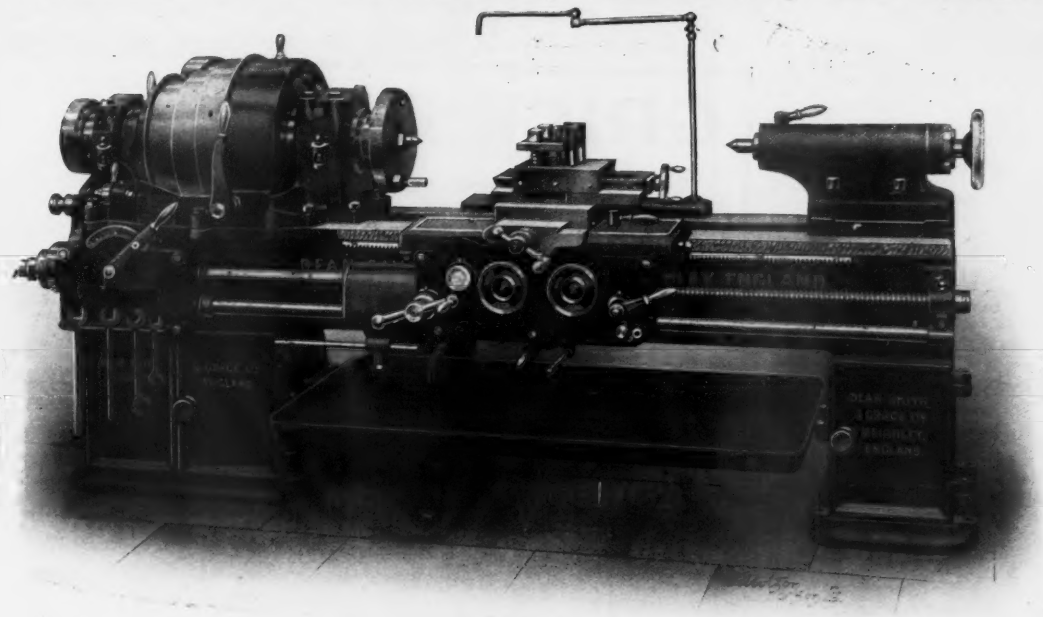

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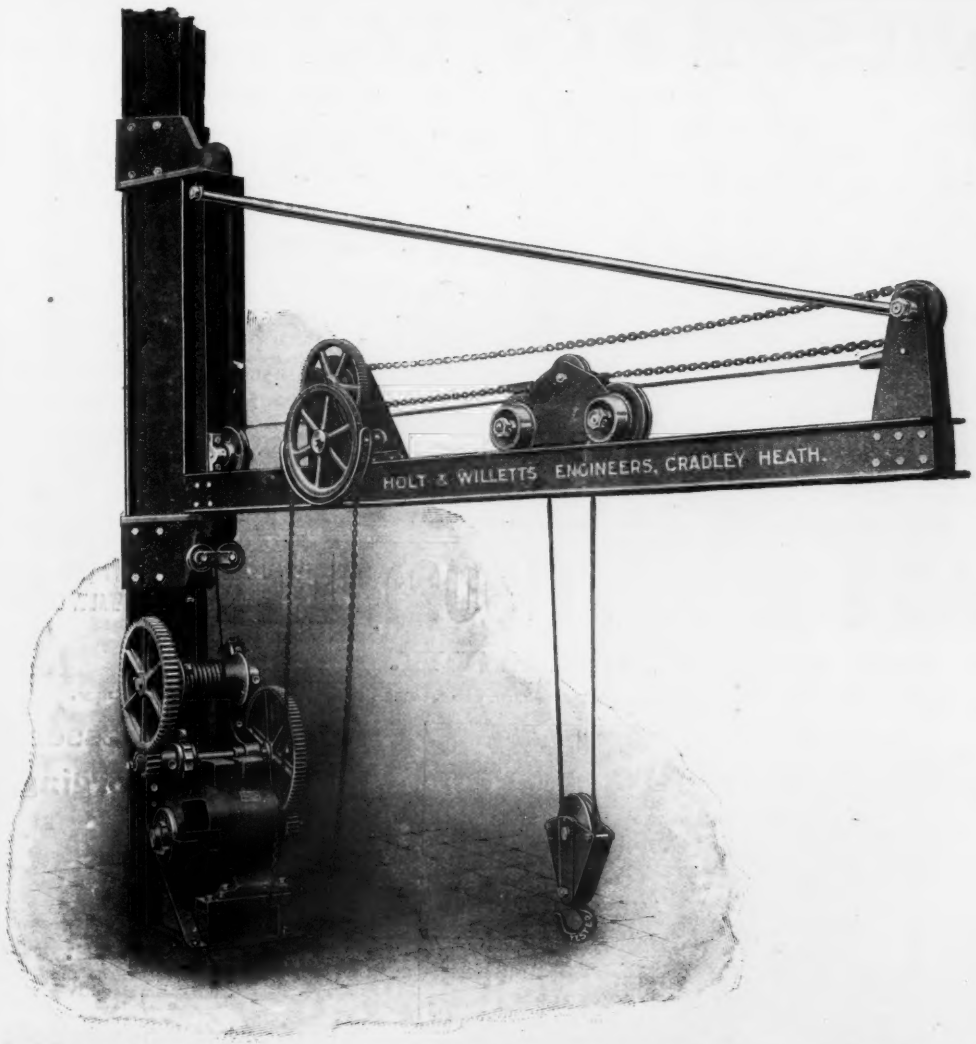

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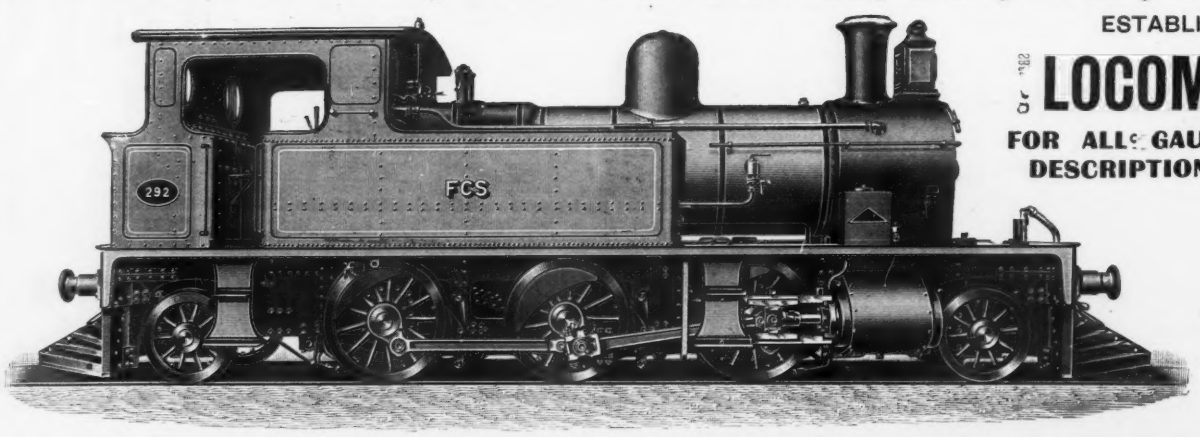

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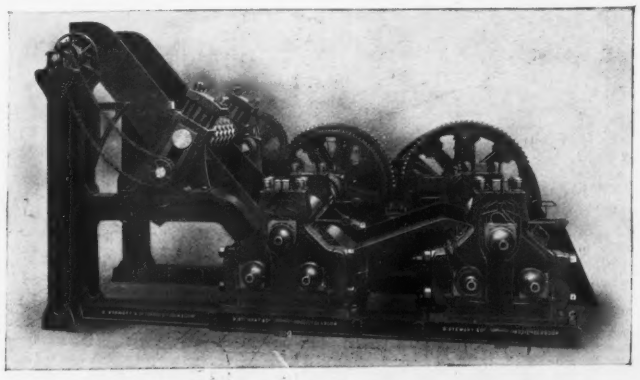

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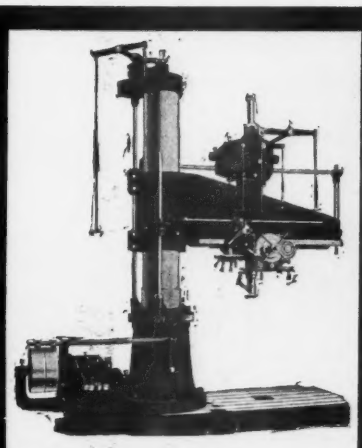

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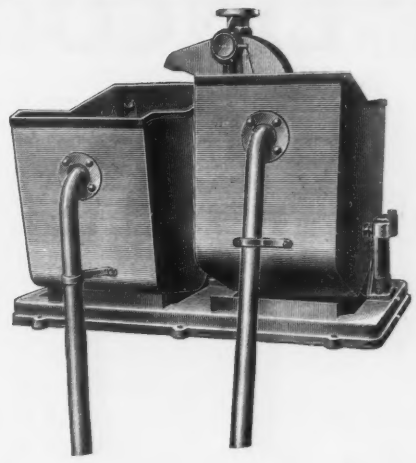

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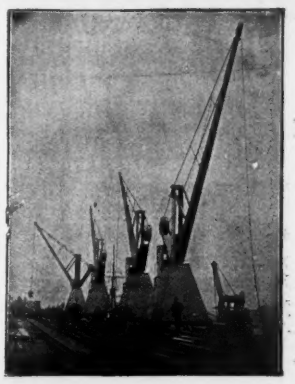

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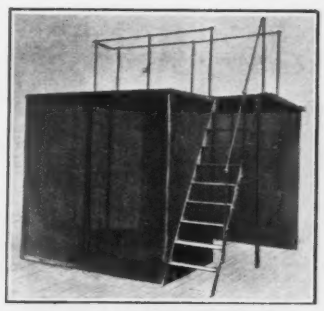

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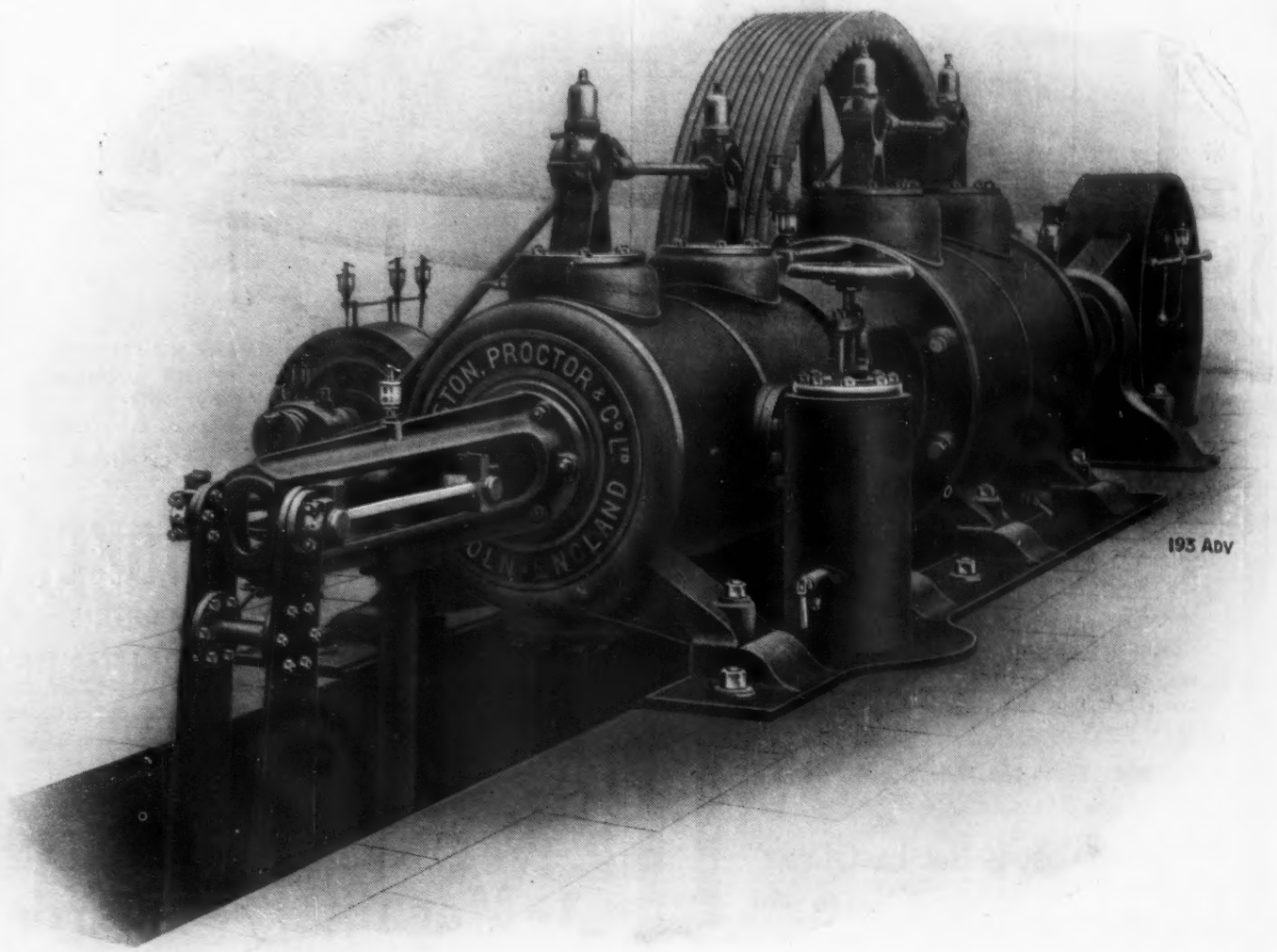

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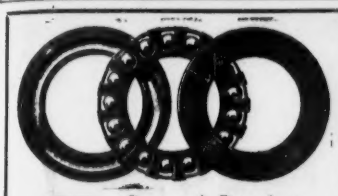

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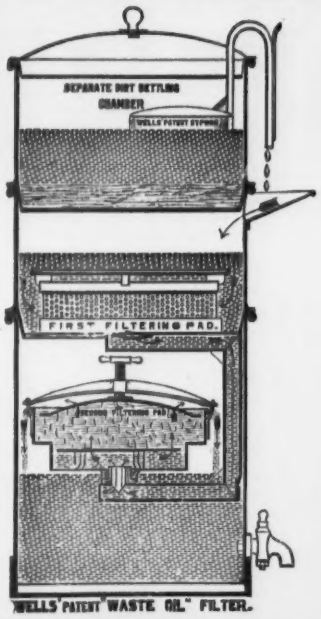

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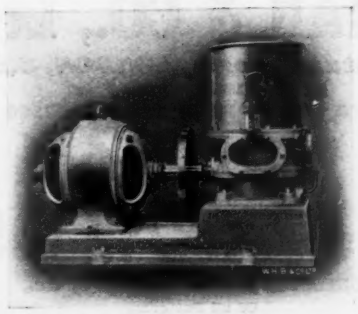

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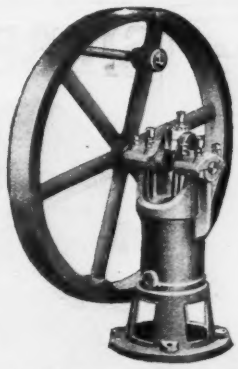

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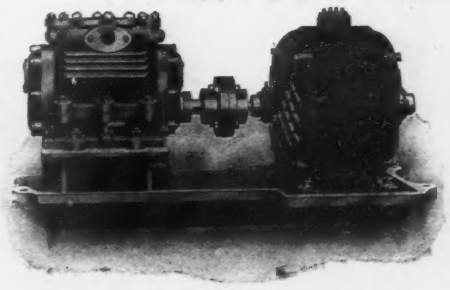

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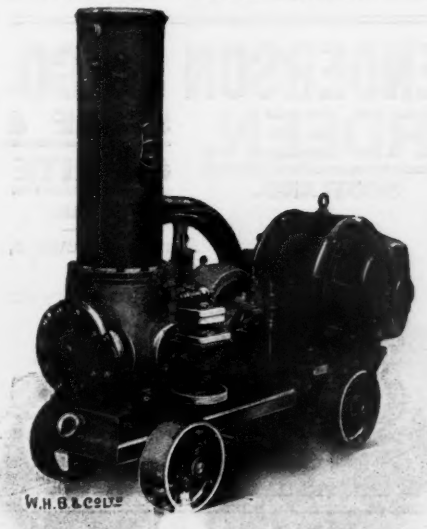

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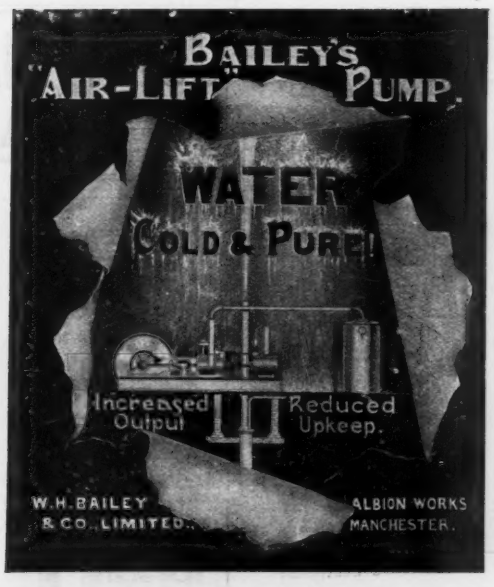

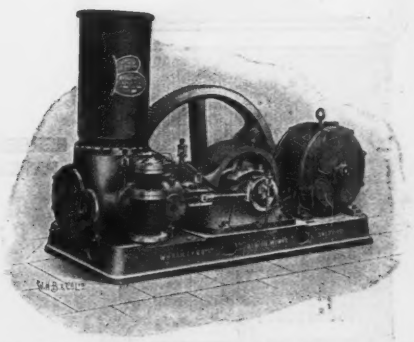

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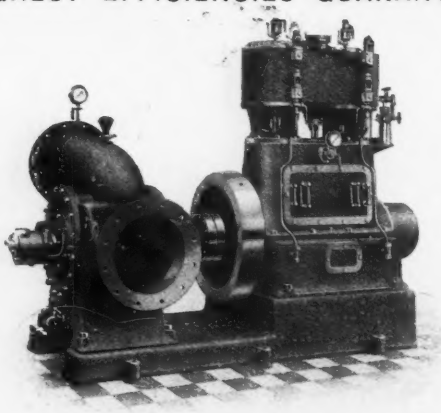

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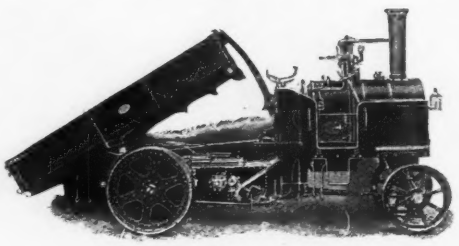

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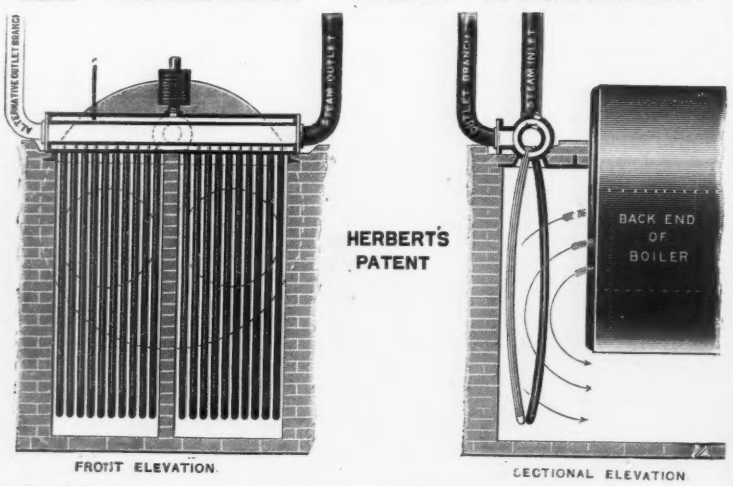

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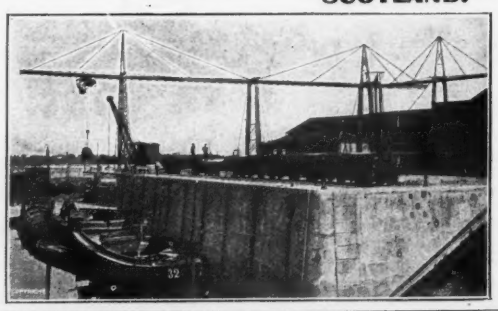

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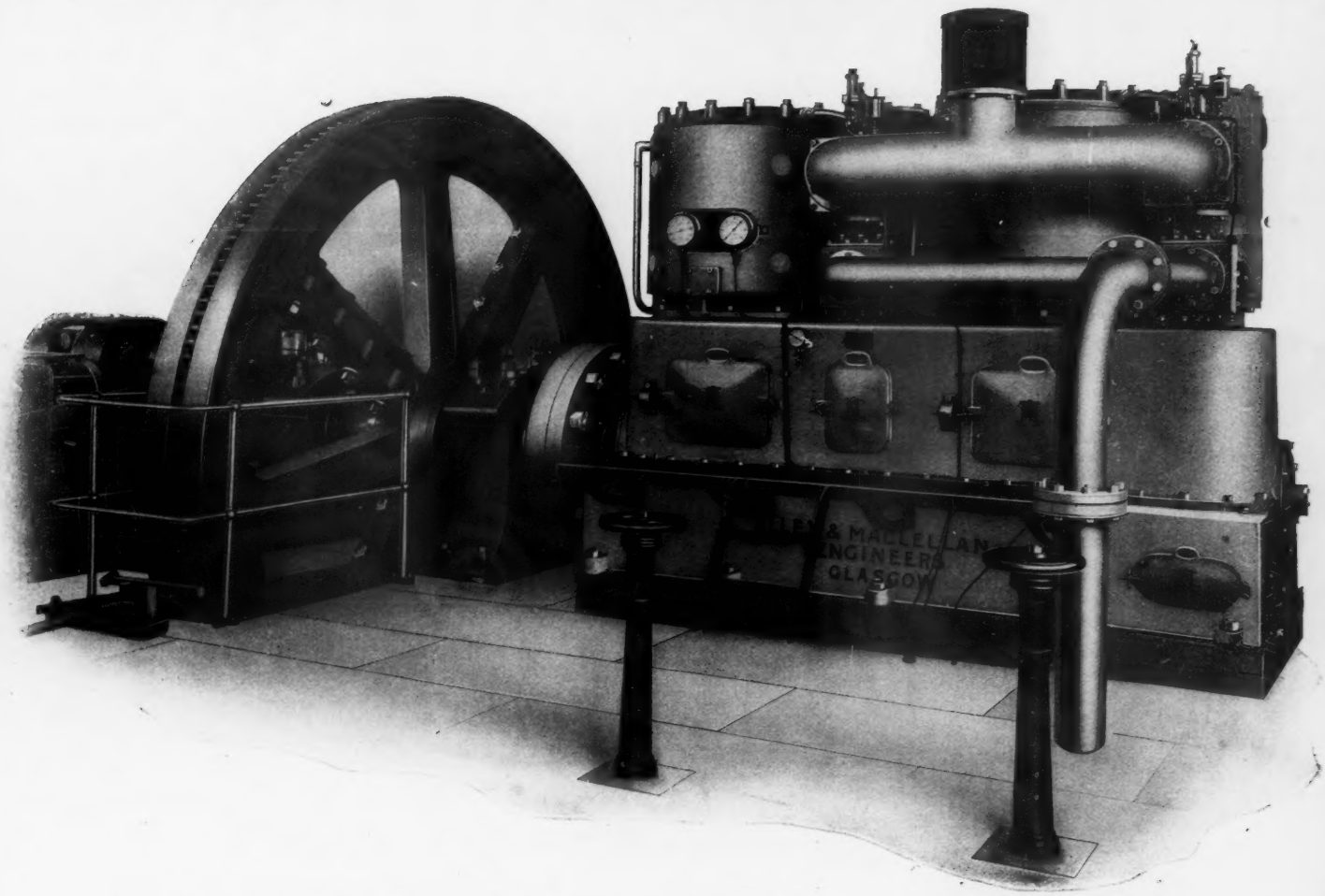

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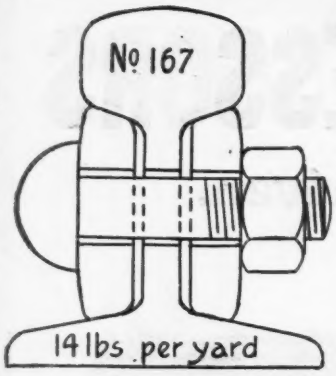
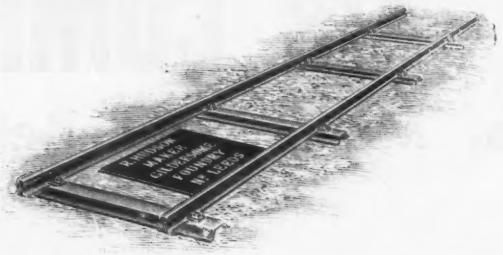
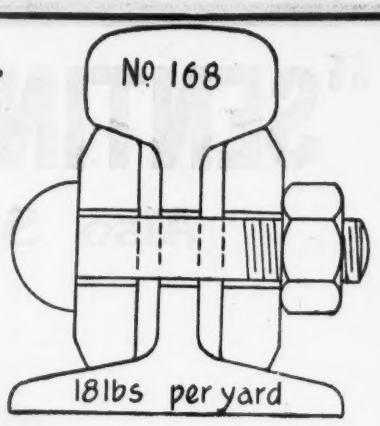


All Weights of Rail from 9 lb. per yard upwards.



No. 230—Portable Railway, fitted with Trough Section of Steel Sleepers and Bolted Clips.



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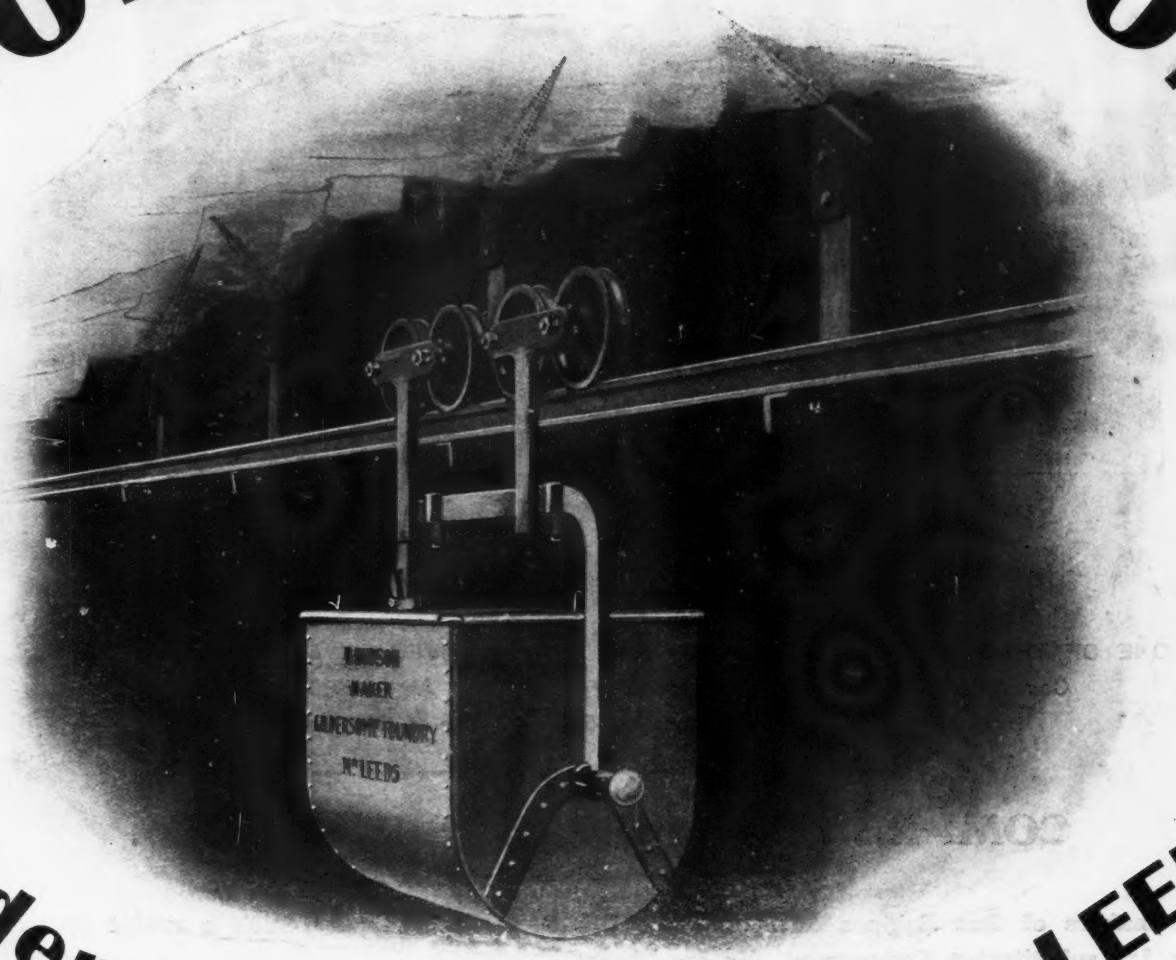
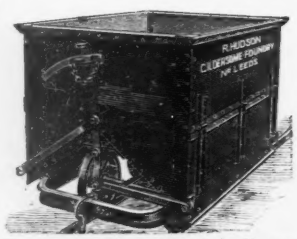
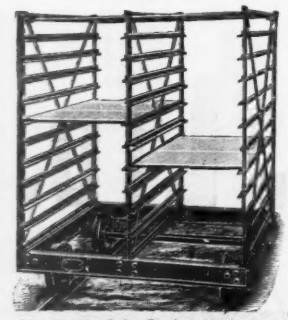


No. E. 307.—Overhead Mono-Railway with Truck.

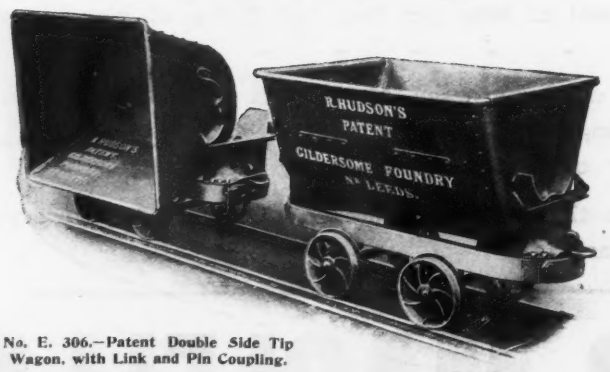
Gildersome Foundry, near LEEDS



No. E. 187.—Steel Side Door Hopper Wagon, discharging on either side of rail.



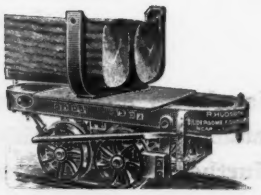
No. E. 68—Cake Drying Wagon.



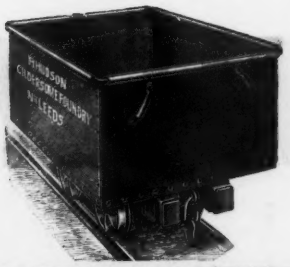
No. E. 306.—Patent Double Side Tip Wagon, with Link and Pin Coupling.

No. E. 117—Self-contained Turntables, all sizes.

No. E. 10—Left-hand Steel Points and Crossings.



No. E. 60.—Bogie Wagon, with Swivel Fork, for carrying Long Balks.



No. E. 101—Steel Plate Colliery Tub.

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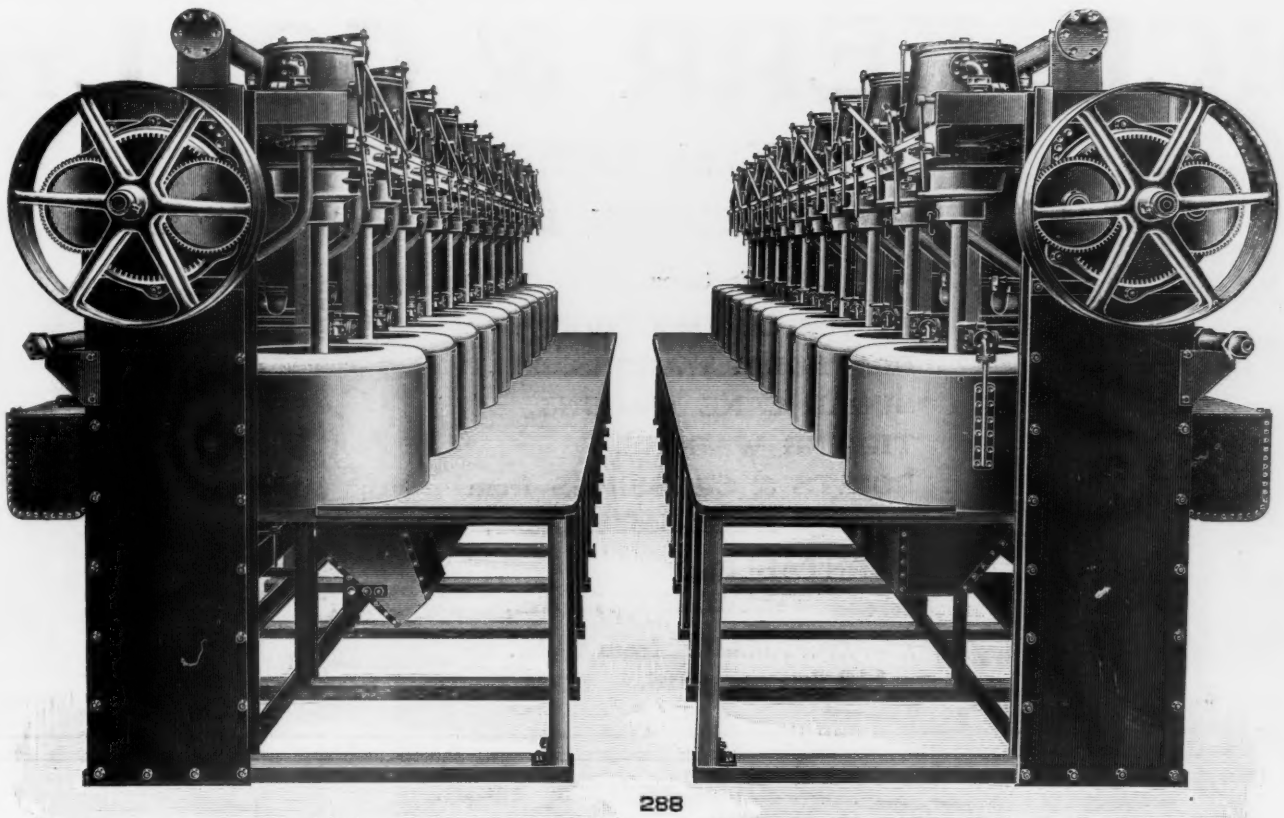

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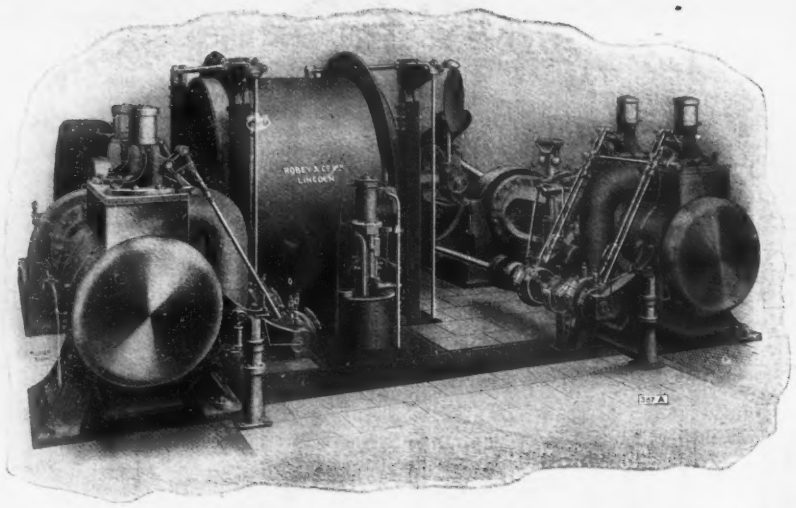

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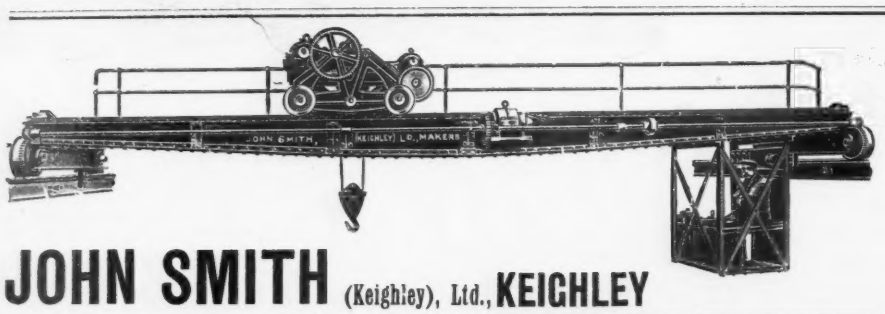

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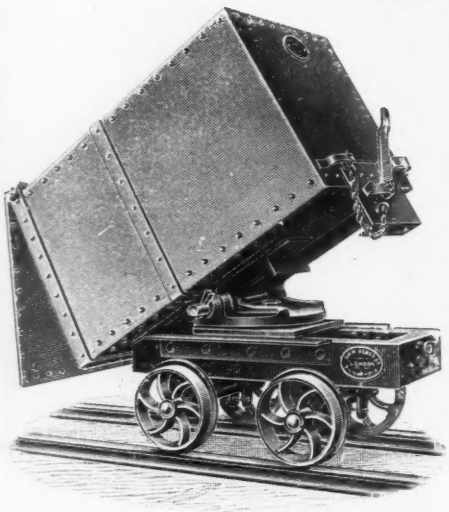

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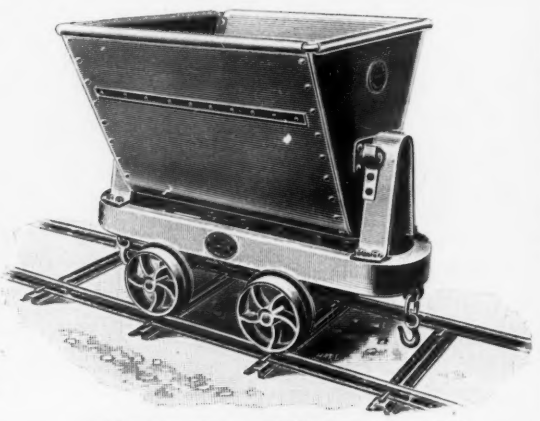

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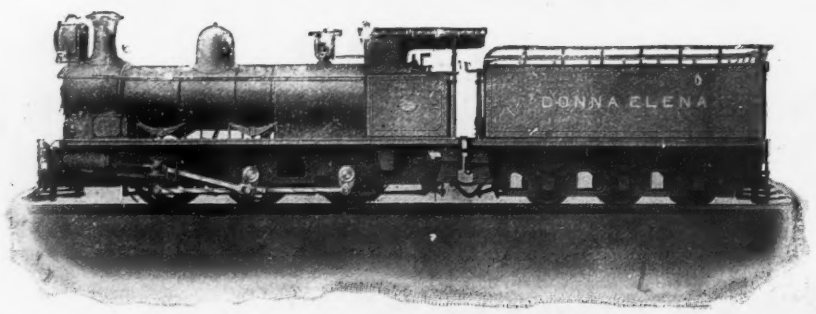

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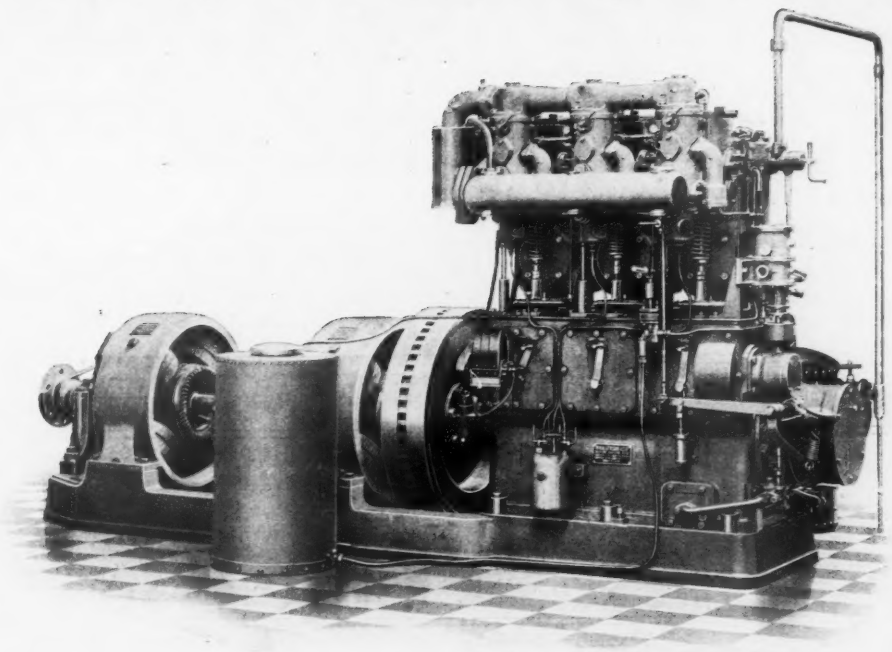

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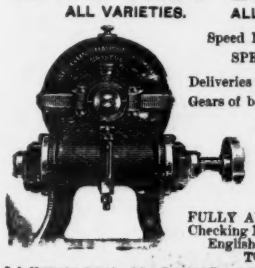
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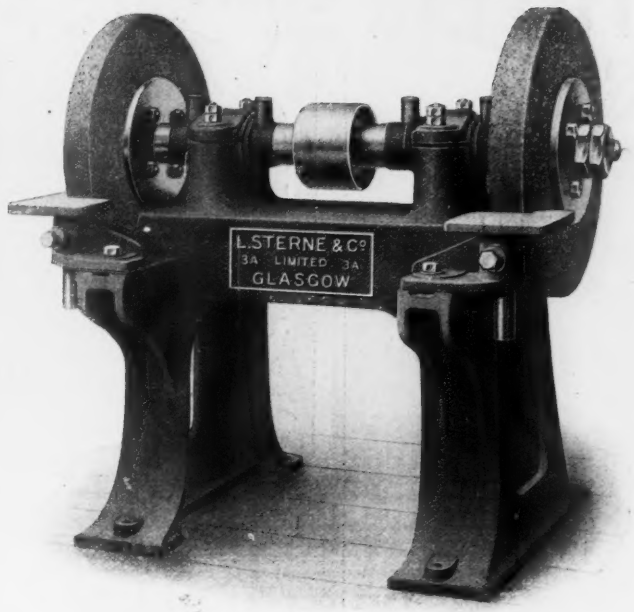

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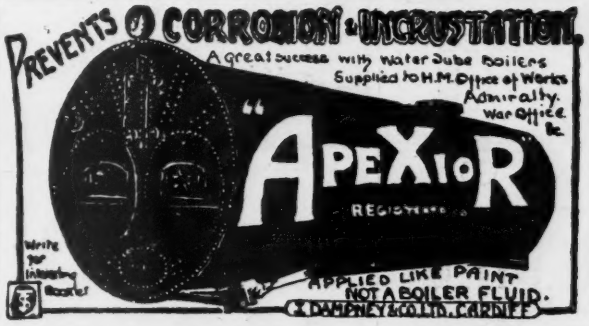

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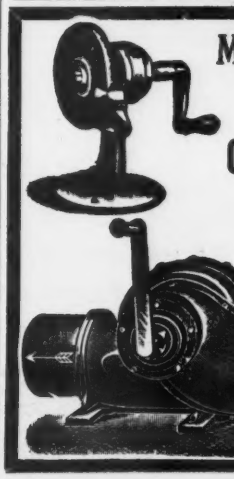

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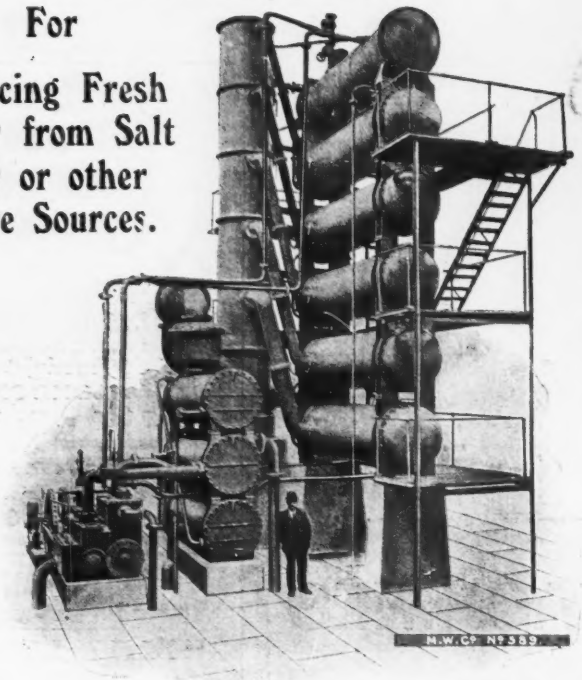

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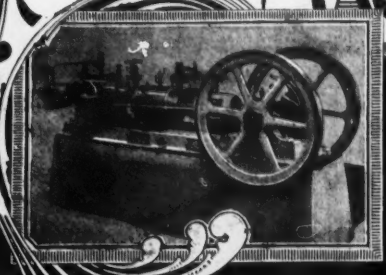

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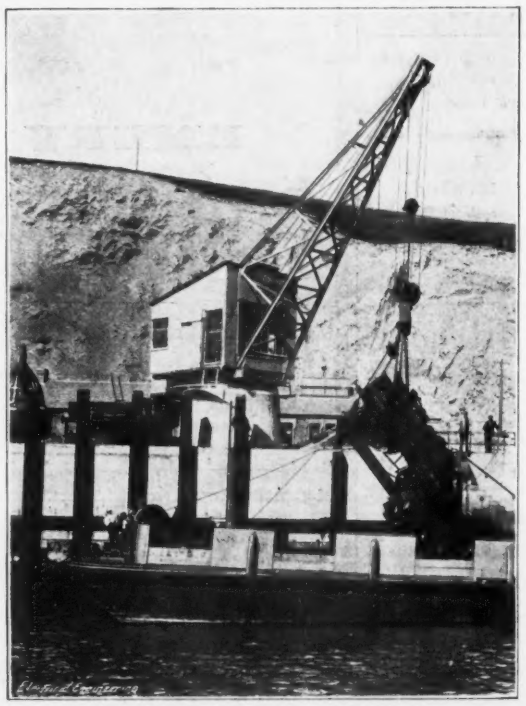

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Fig. 916: Electric Coaling Crane.

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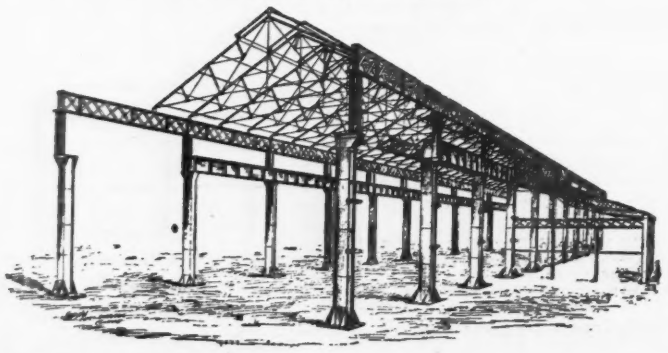

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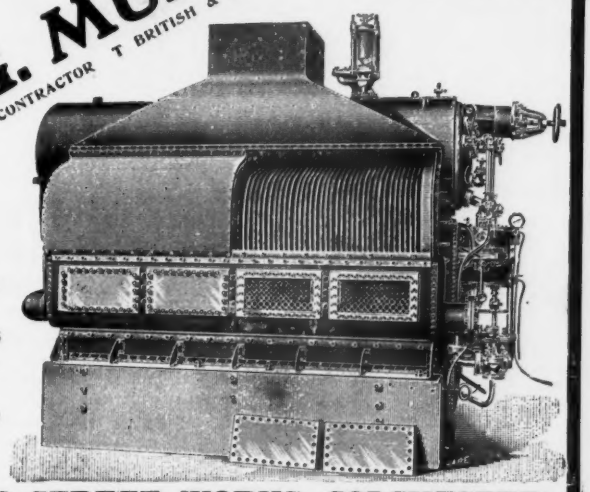

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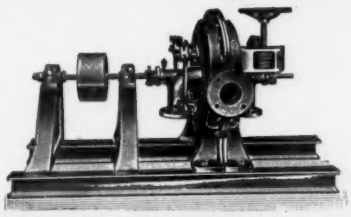

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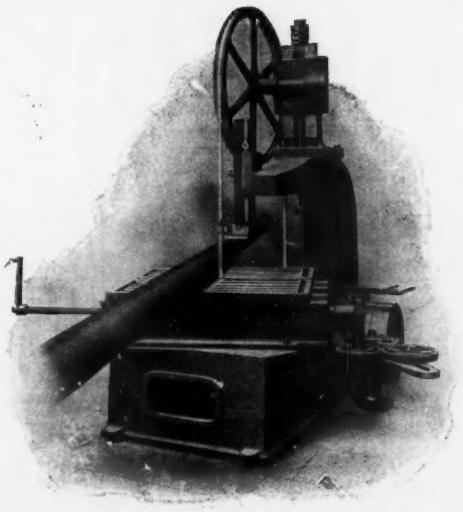

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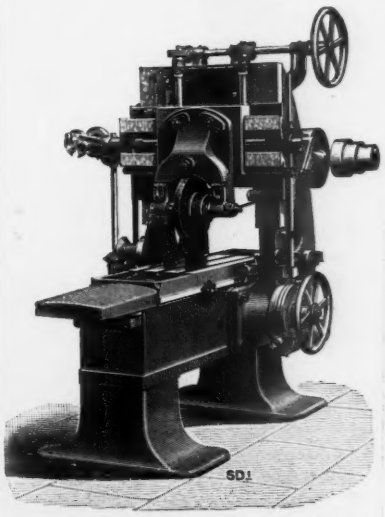

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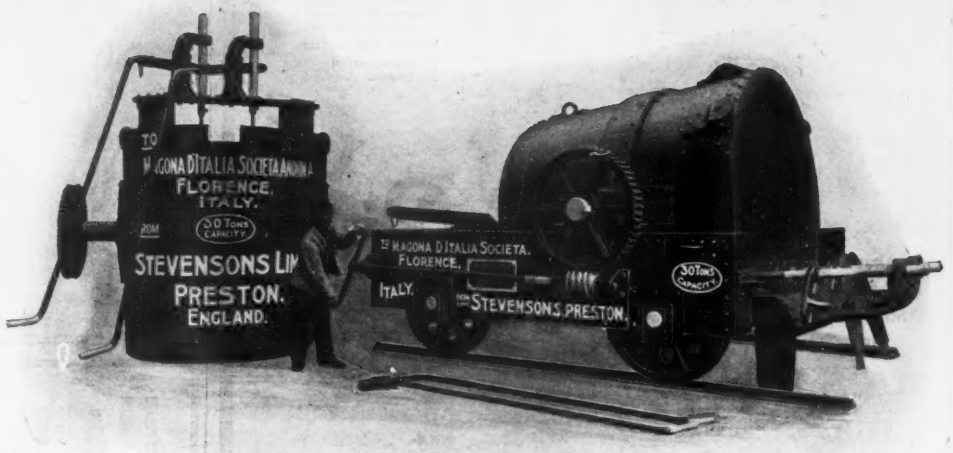

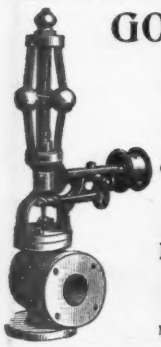

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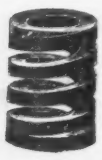

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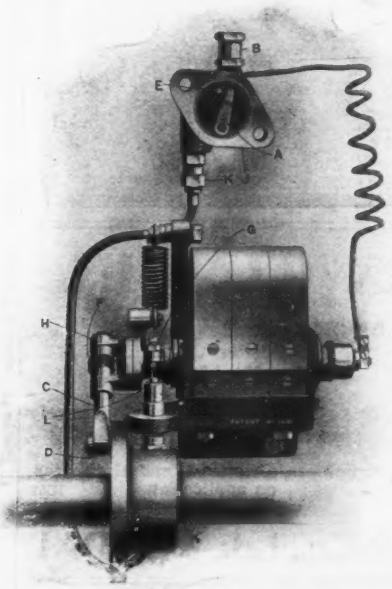

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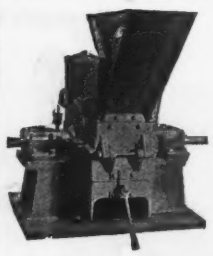

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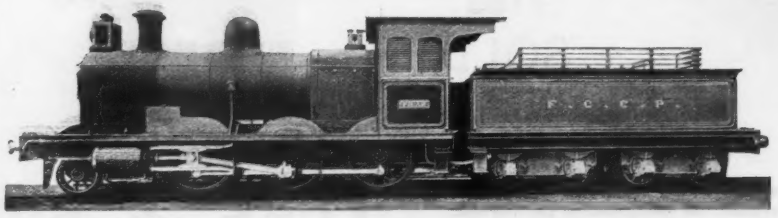

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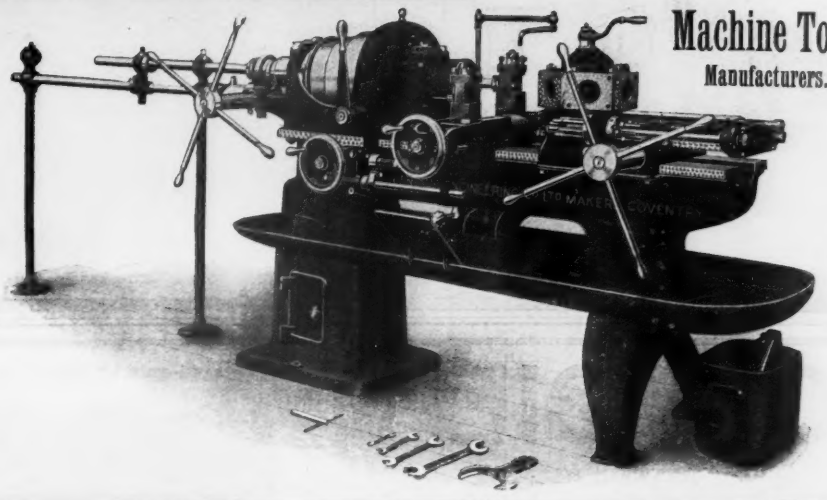

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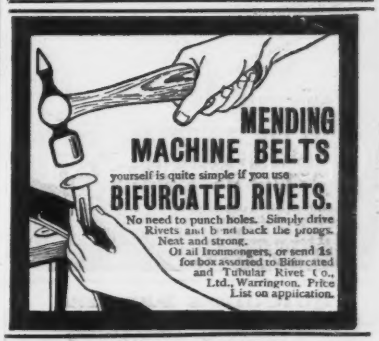

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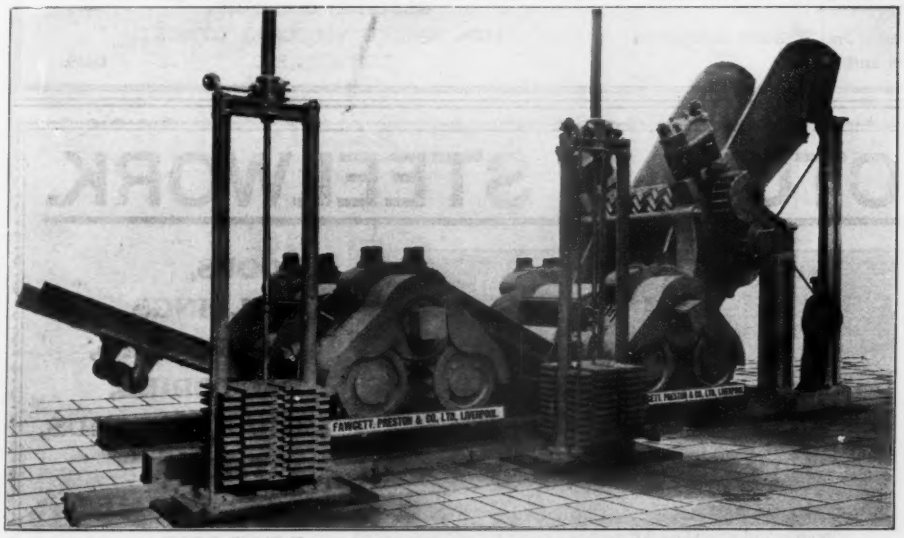

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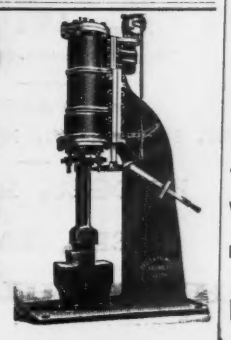

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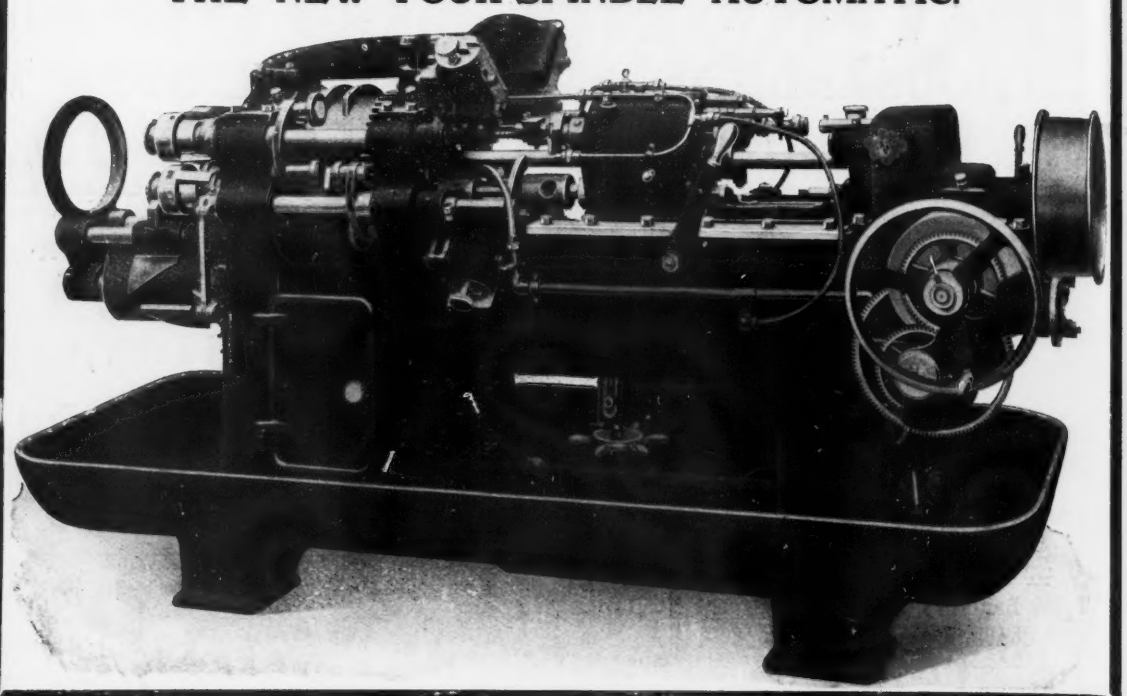

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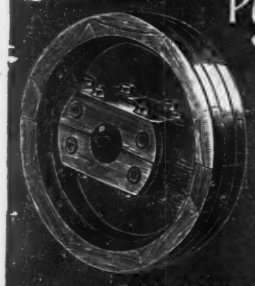

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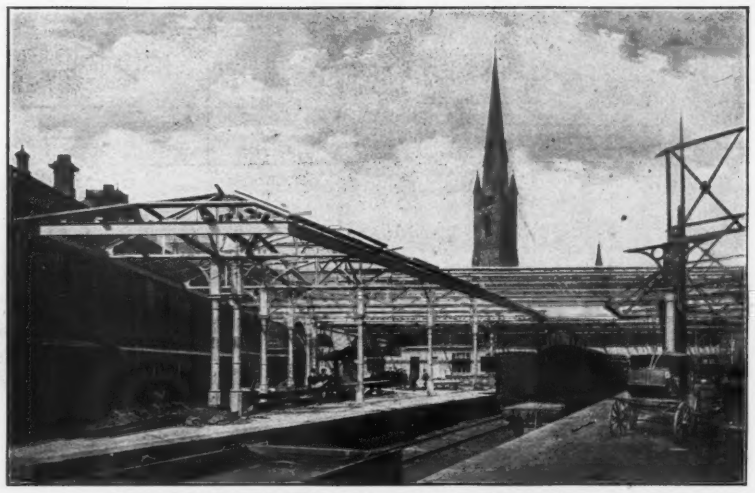

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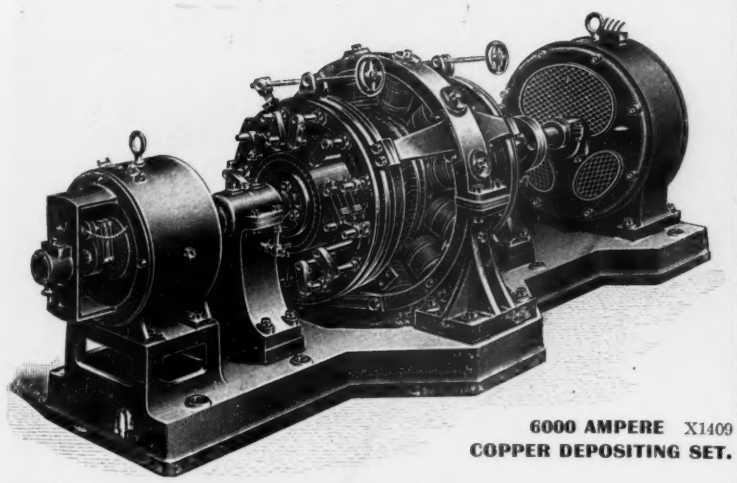

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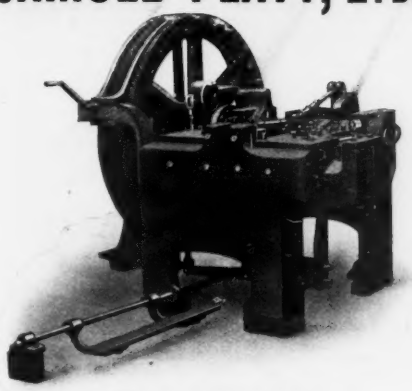

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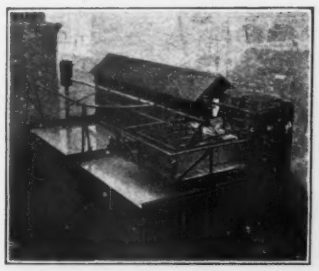

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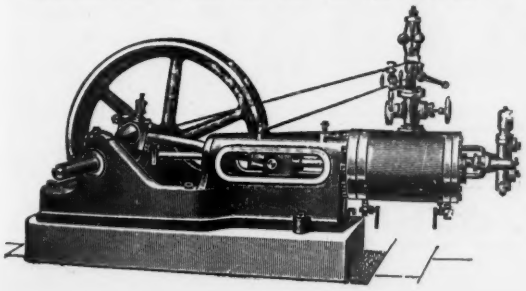

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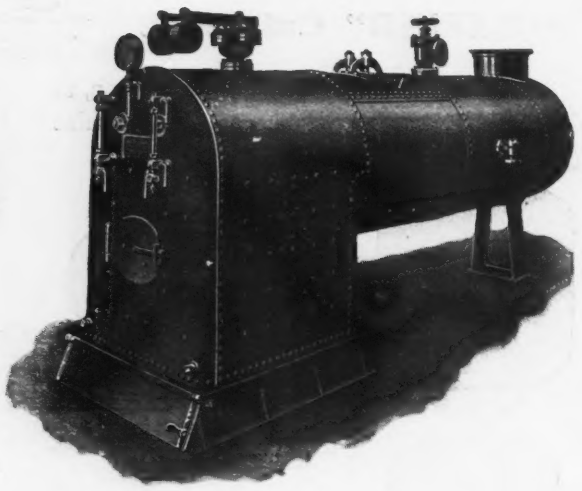

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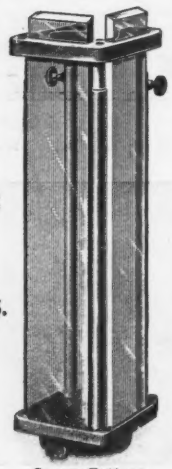
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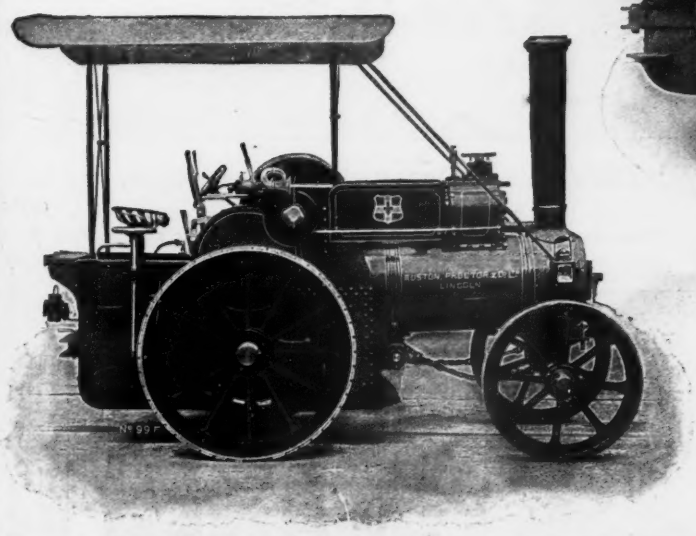

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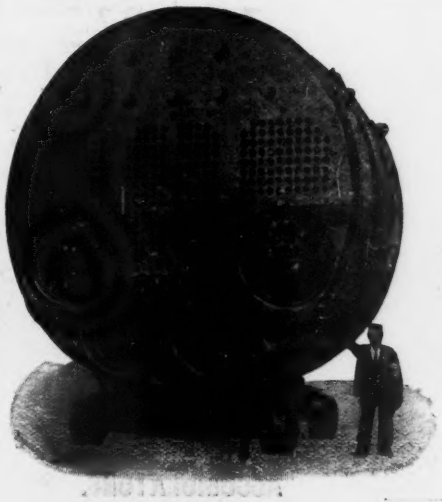

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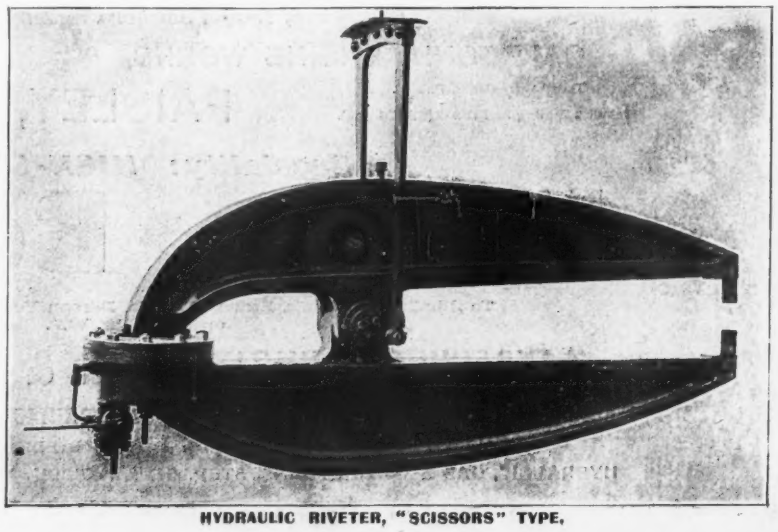

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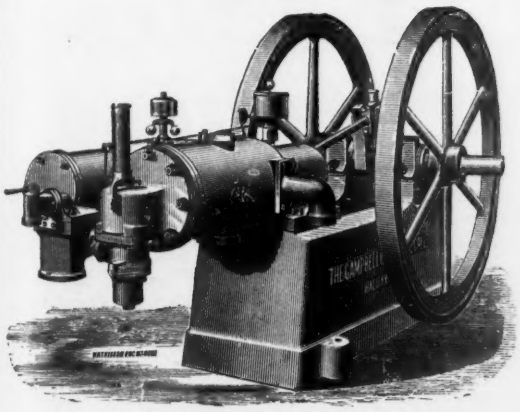

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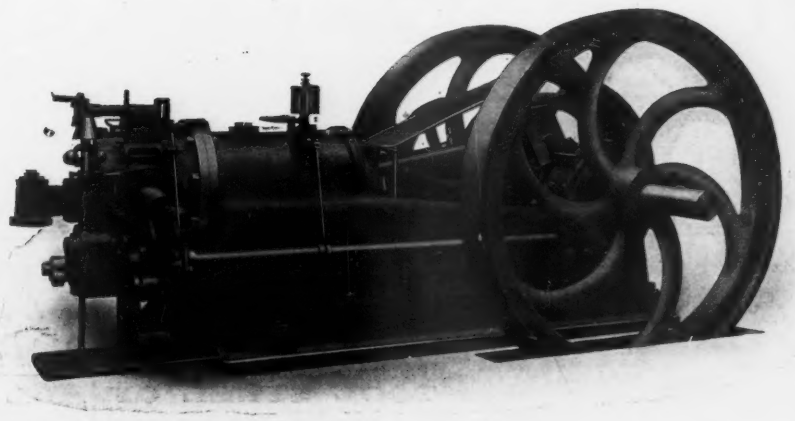

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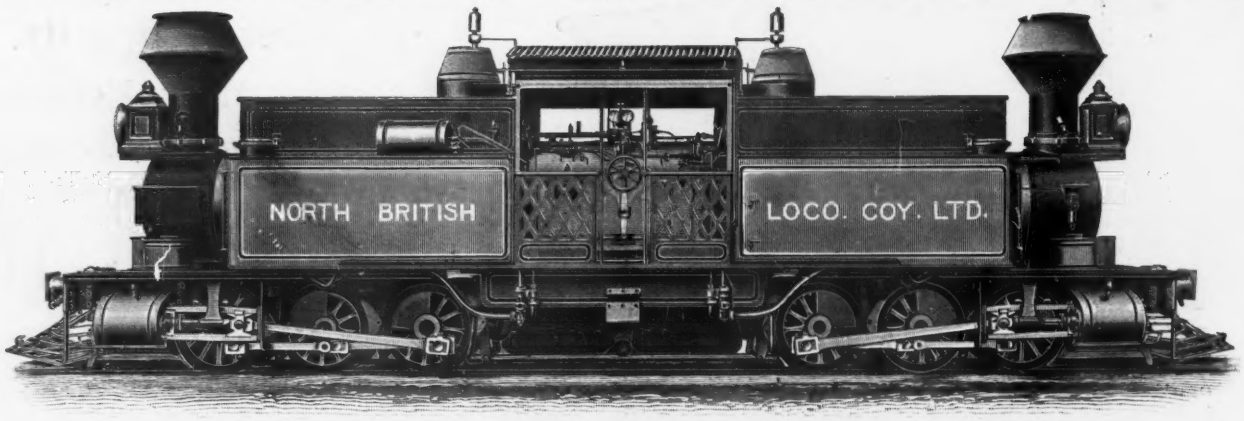

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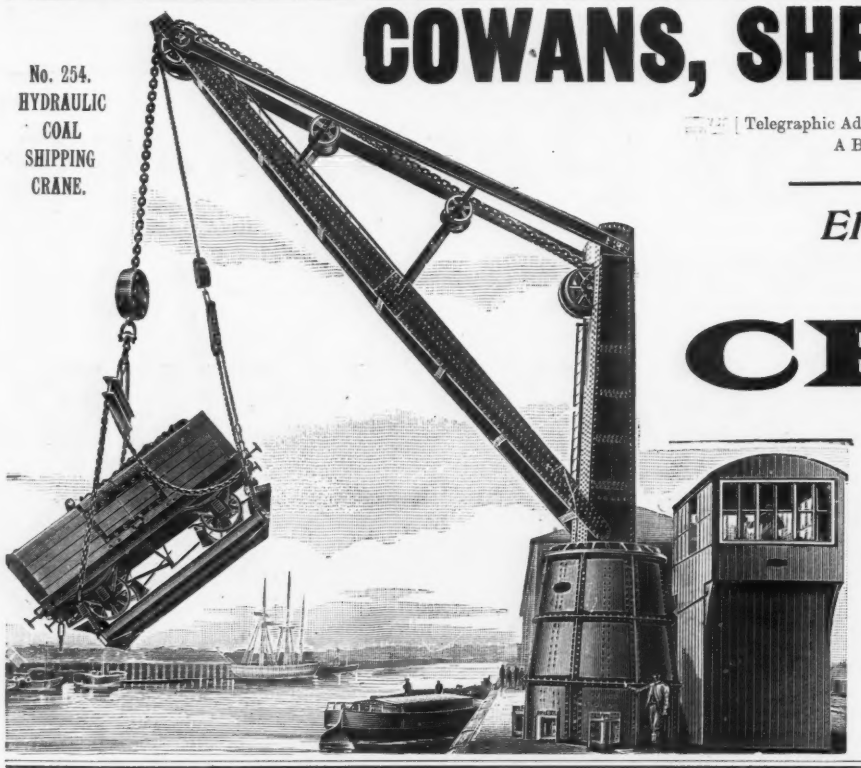

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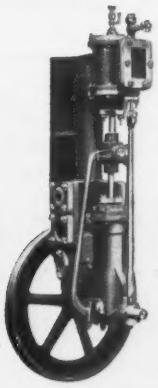

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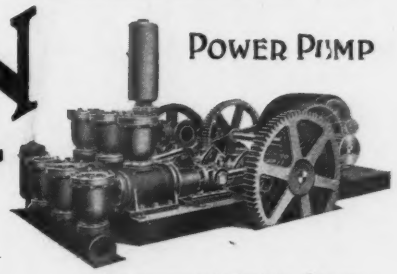

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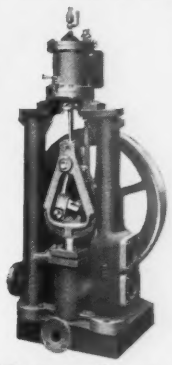

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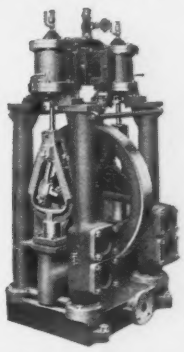

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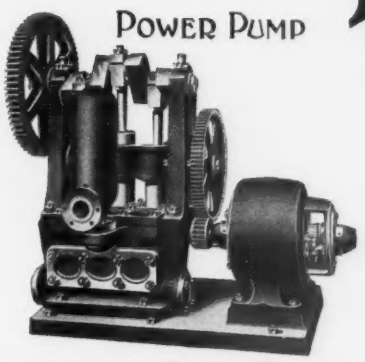

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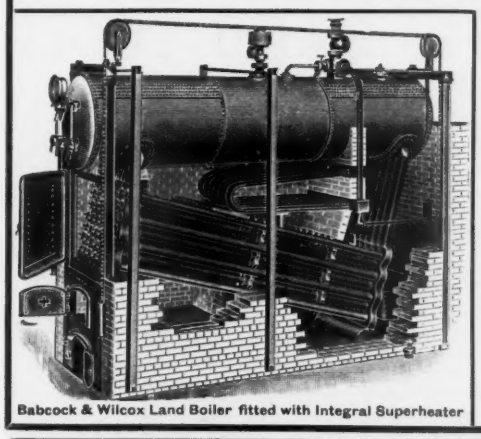

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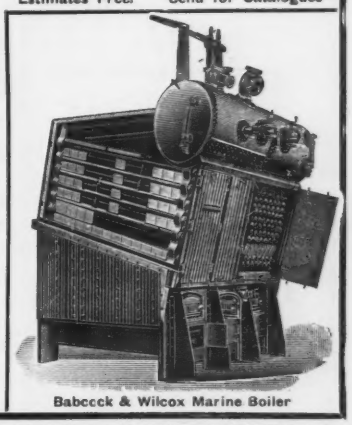

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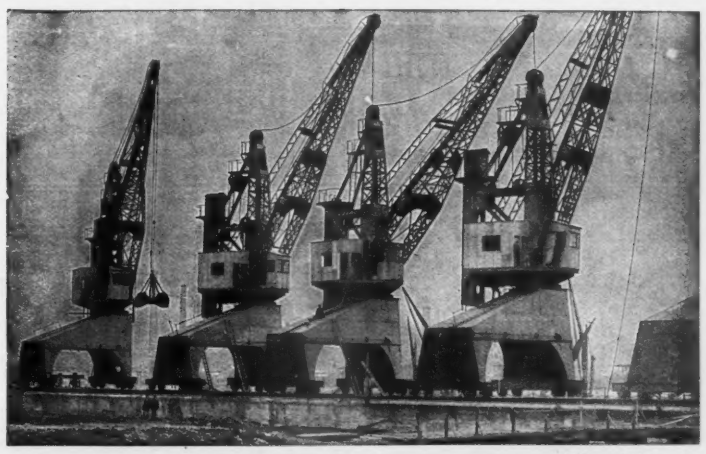

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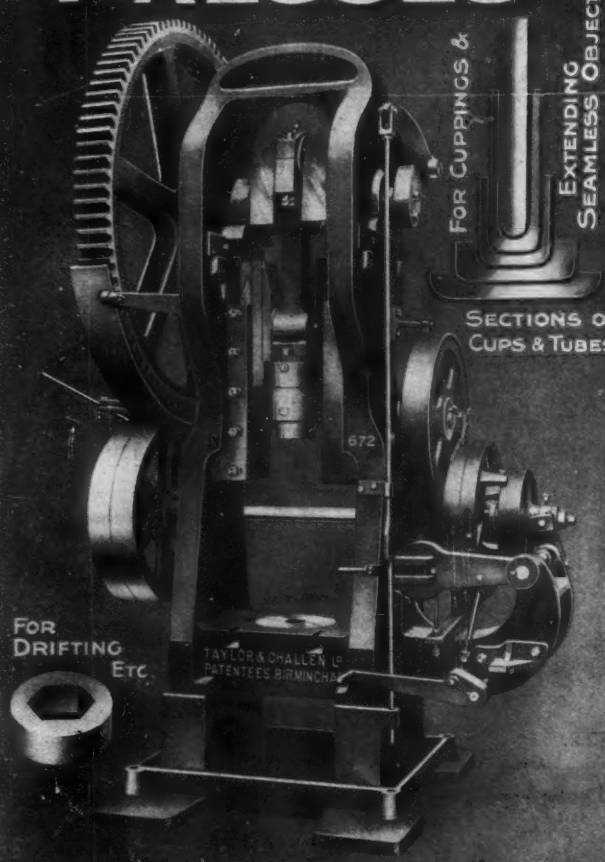

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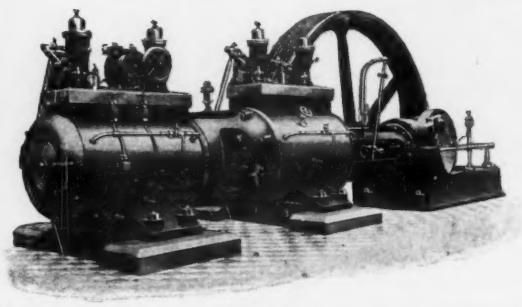

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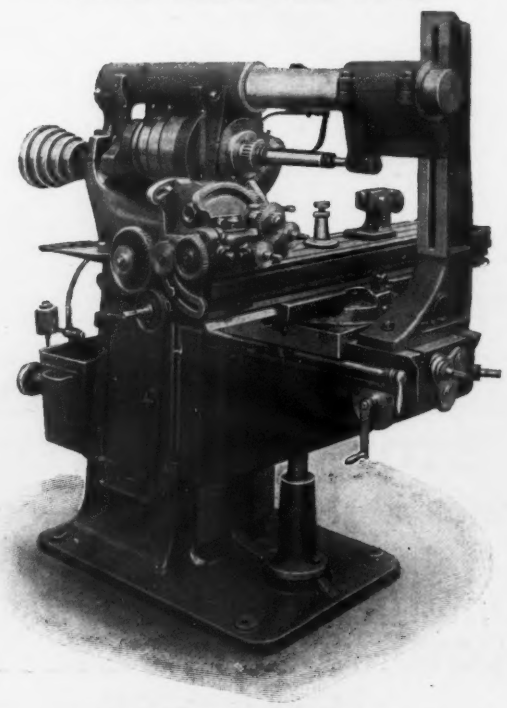

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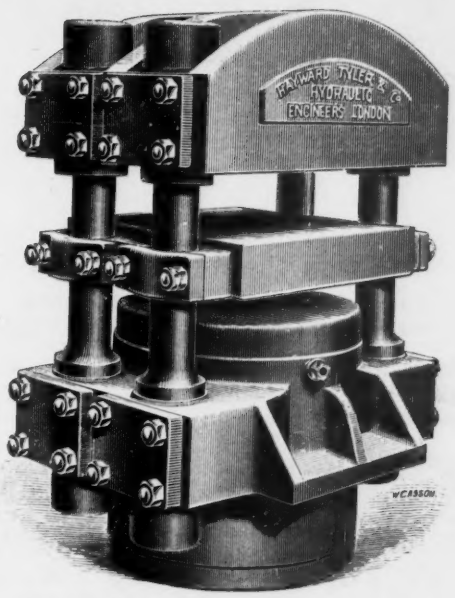

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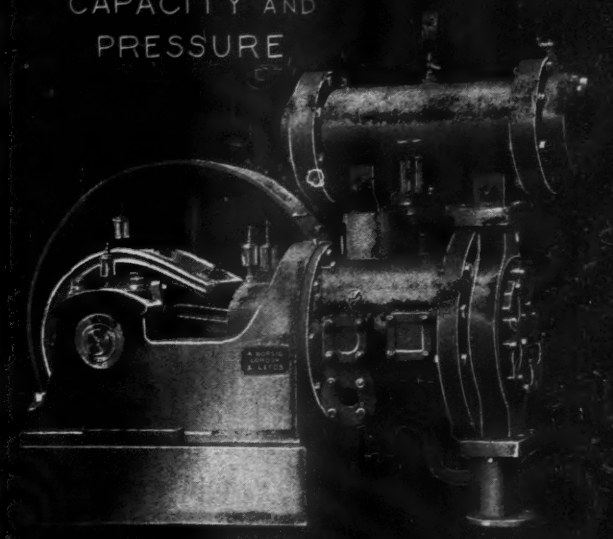

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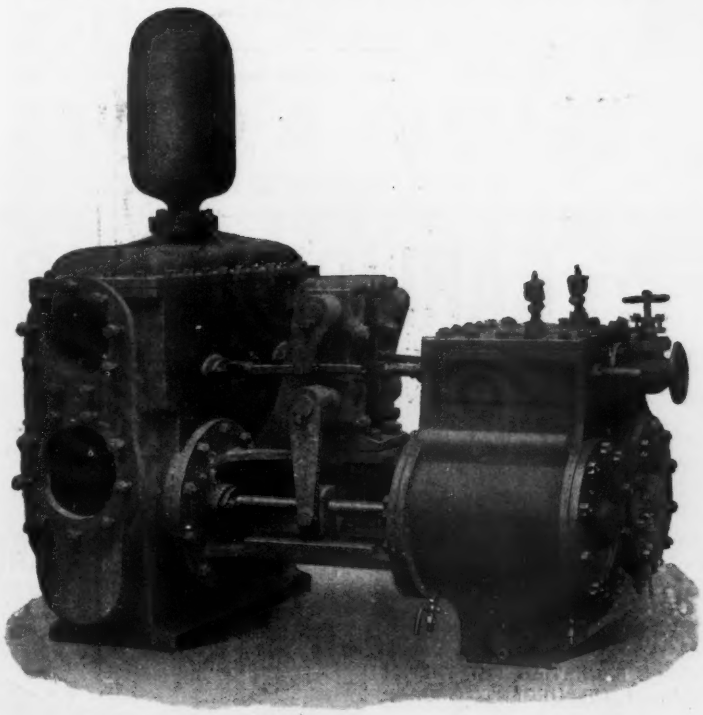

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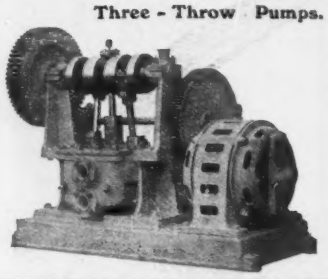

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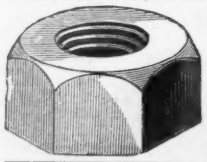

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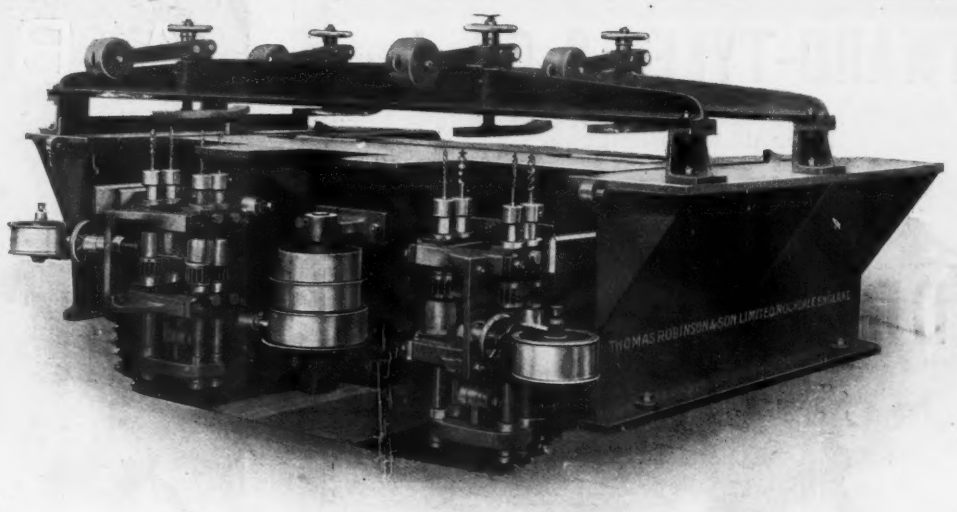

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Built in Six Styles, with 4, 6 or 8 Boring Spindles, either fixed or adjustable, taking sleepers 6in. by 12in. and 10ft. long, suitable for 4ft. 8½in. gauge.

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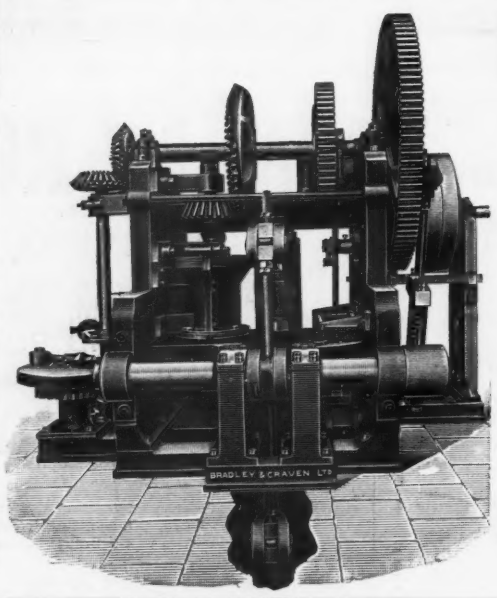

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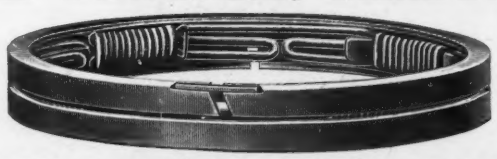

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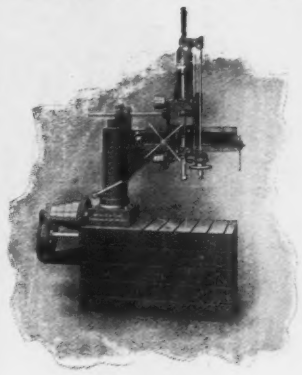
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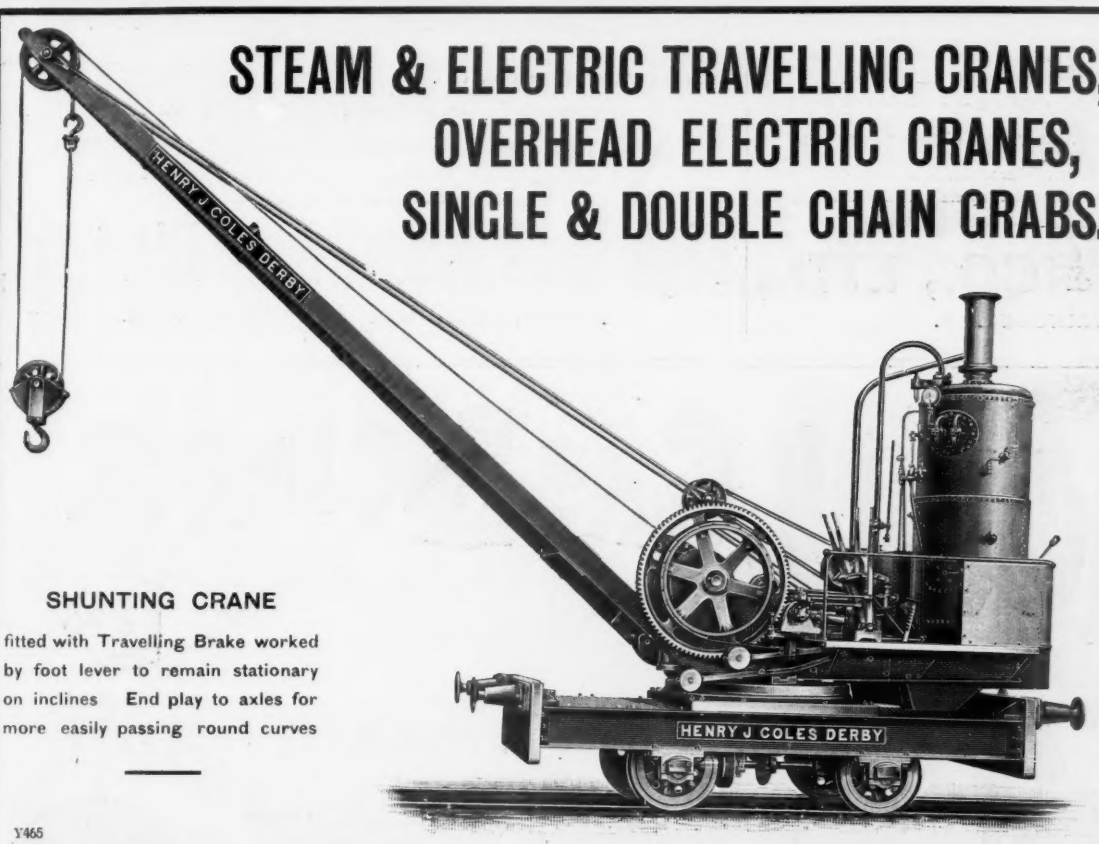

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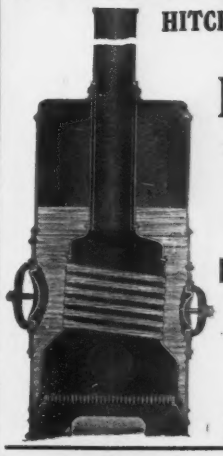
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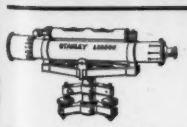
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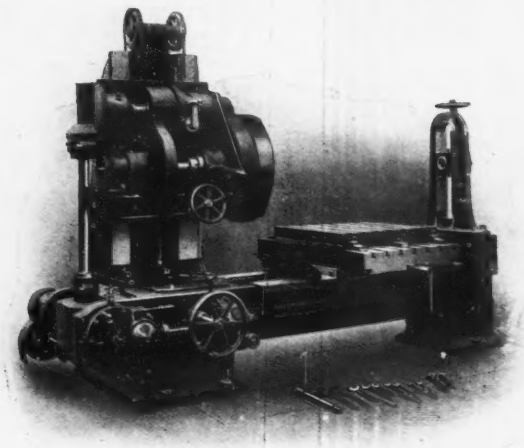

We are the original makers, and have manufactured and sold close upon 500 of this class of machine during the last sixteen years.

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Power transmitted to the spindle by gearing. No auxiliary belt drive necessitating cutting away of upright and spindle frame.

Patent Feed Gear Box, with safety clutch and interlocking devices to feeds.

Spindle speeds suitable for drilling.

Wide range of speeds—48 speeds to spindle in cone-driven machines, and 32 speeds to spindle in machines with single pulley drive.

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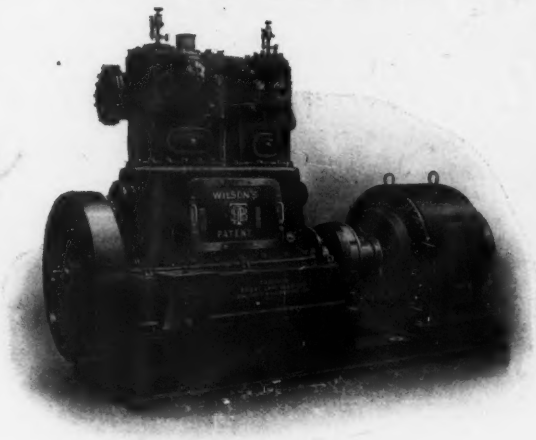
Forced Lubrication.



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NEW CHEAP POWER.

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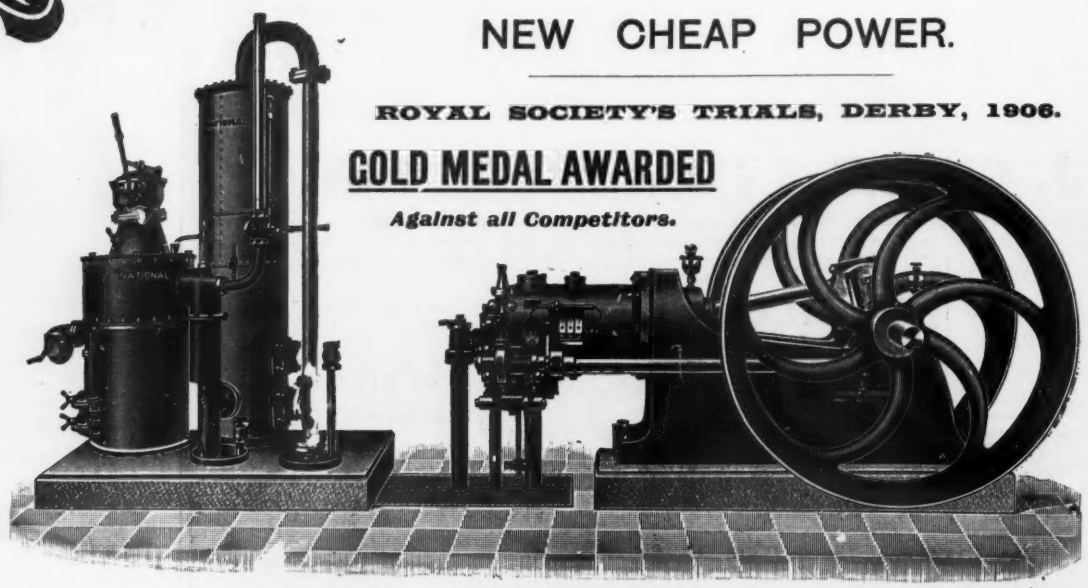

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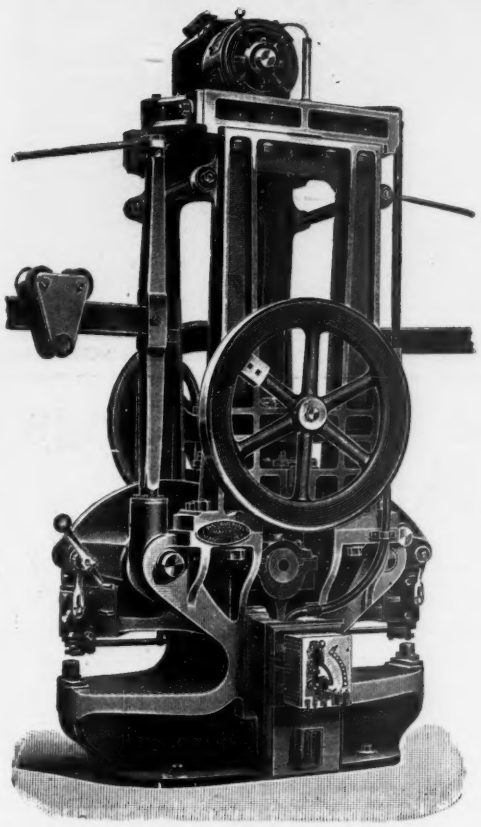

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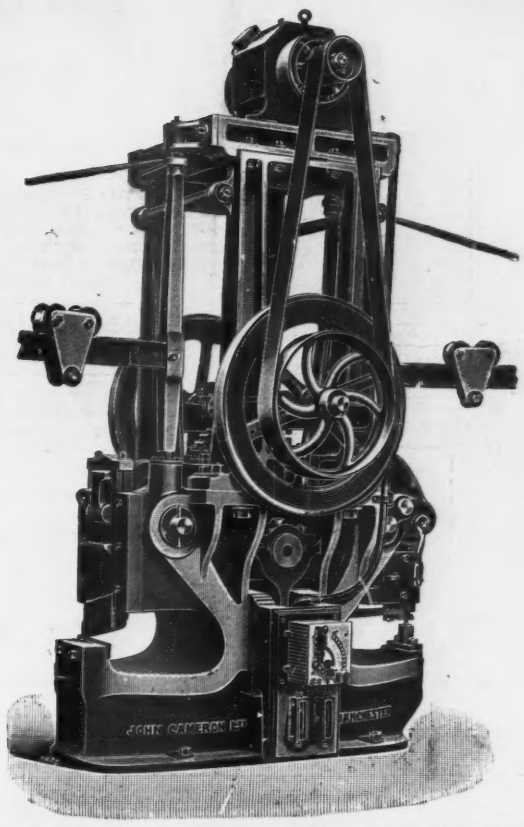

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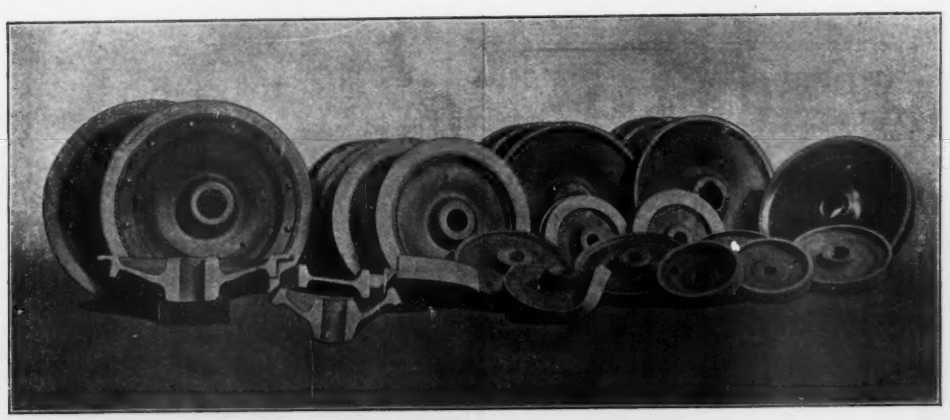

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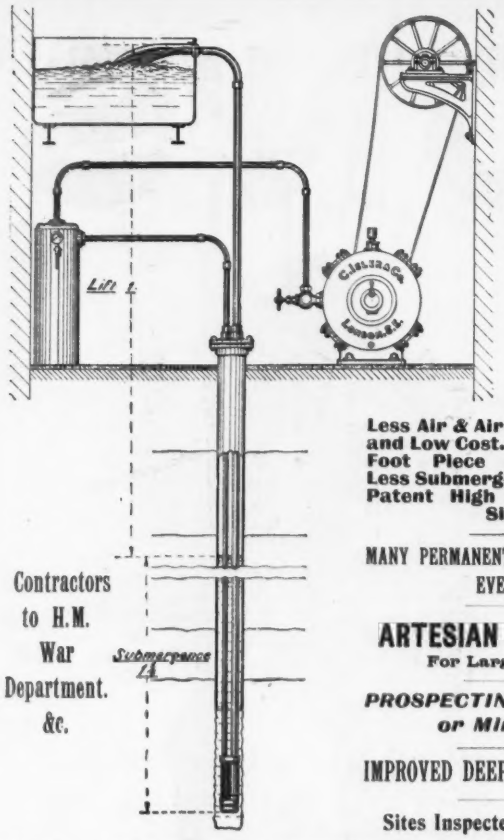

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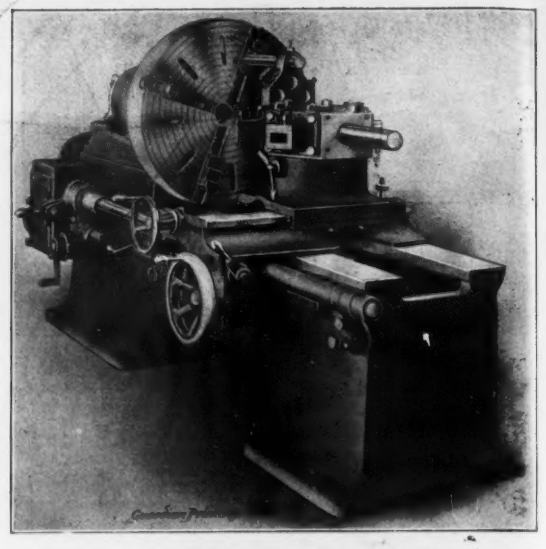

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A red leaded joint has to be taken apart. It takes time, strength and two men. Frequently the piping or tools are broken.—EXPENSE!

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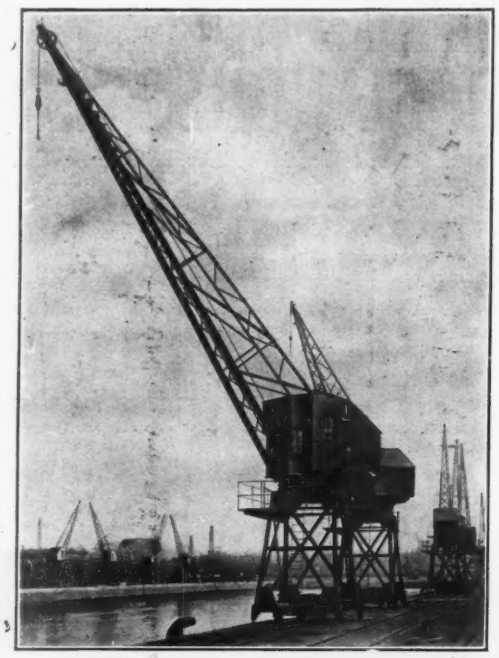

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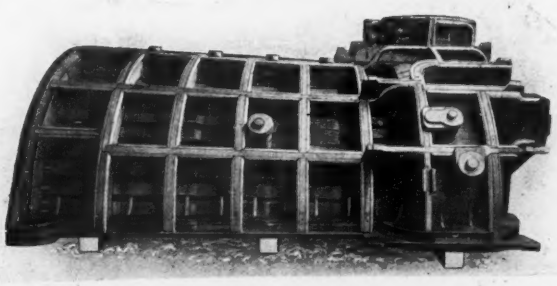

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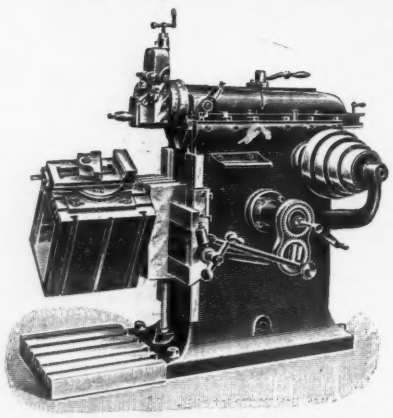

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With Stationary or Traversing Heads, and One or Two Tables, 6in. to 30in. Stroke.

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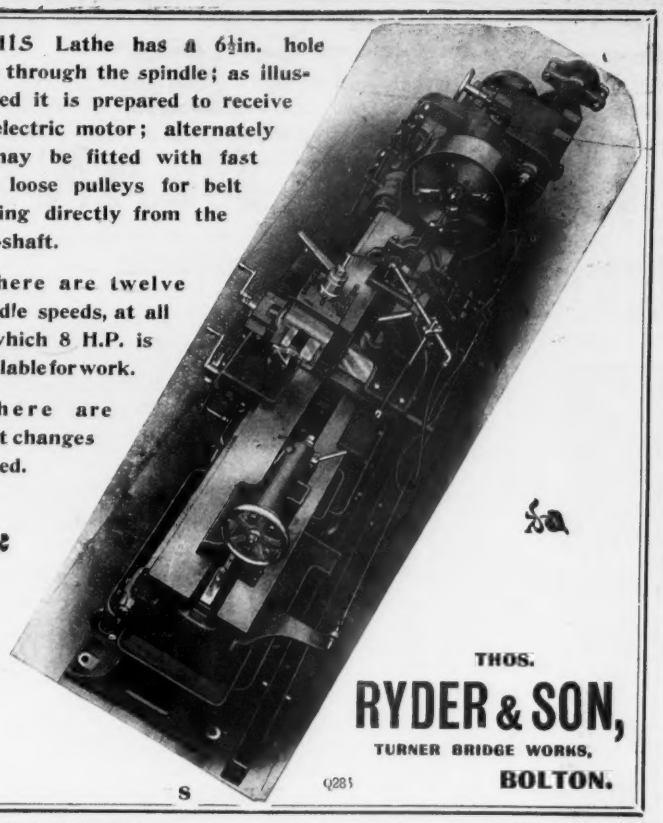
There are twelve spindle speeds, at all of which 8 H.P. is available for work.

There are eight changes of feed.



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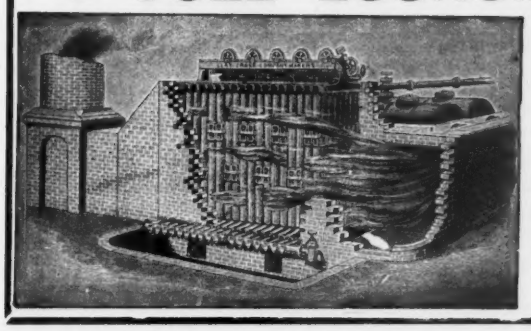

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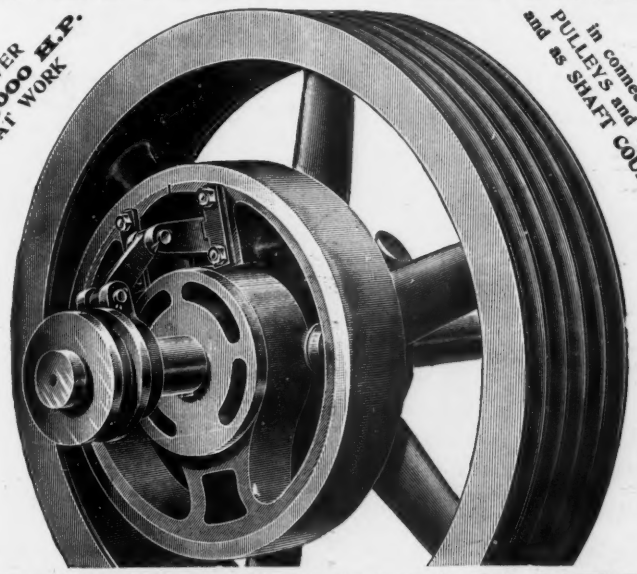

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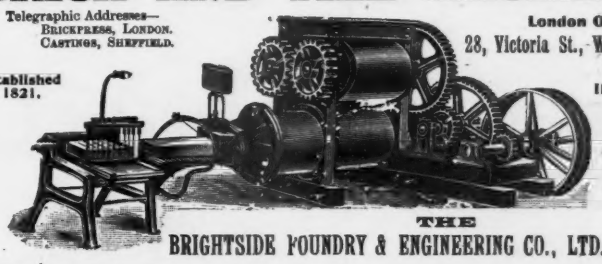

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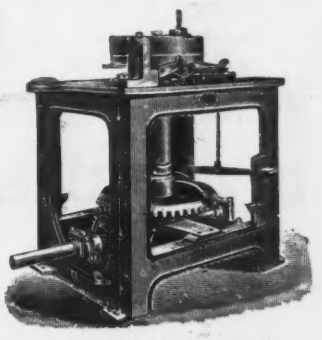

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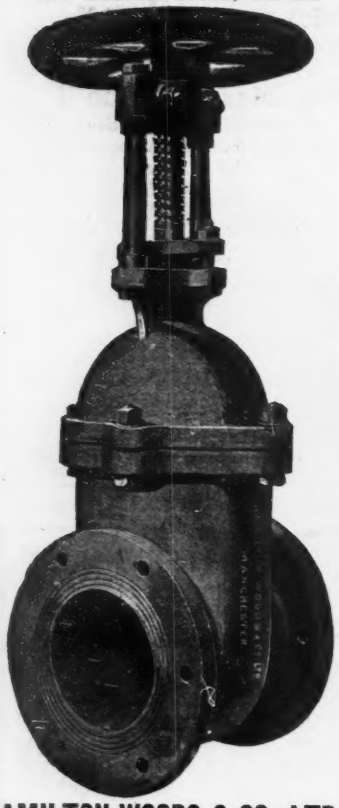

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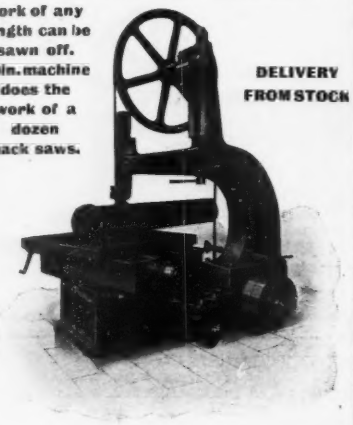

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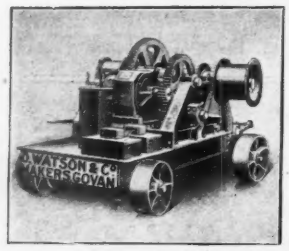

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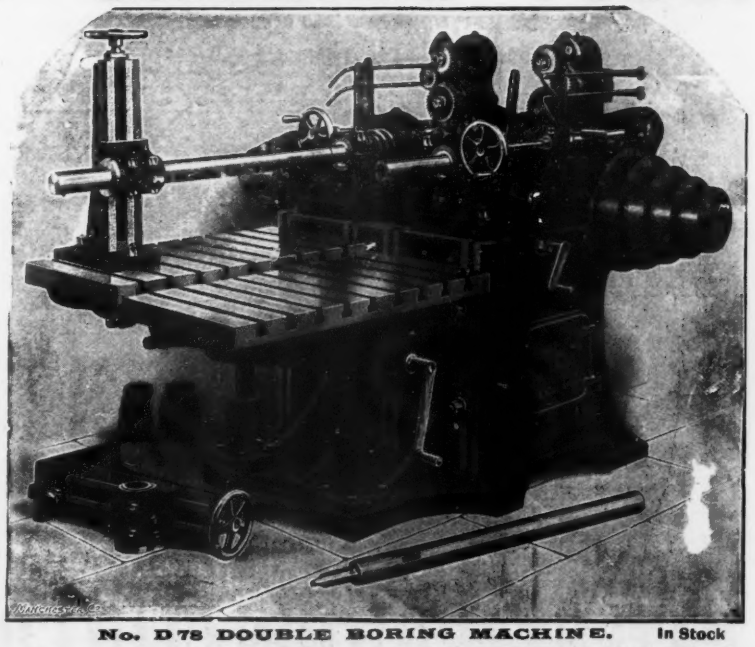

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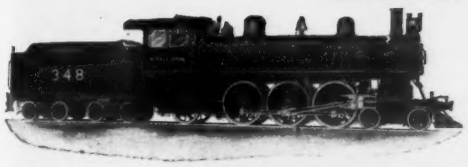

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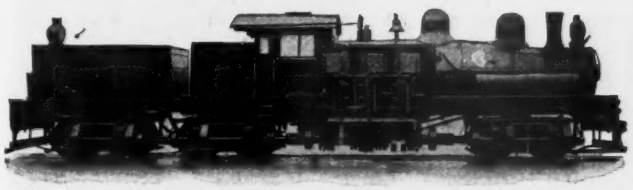

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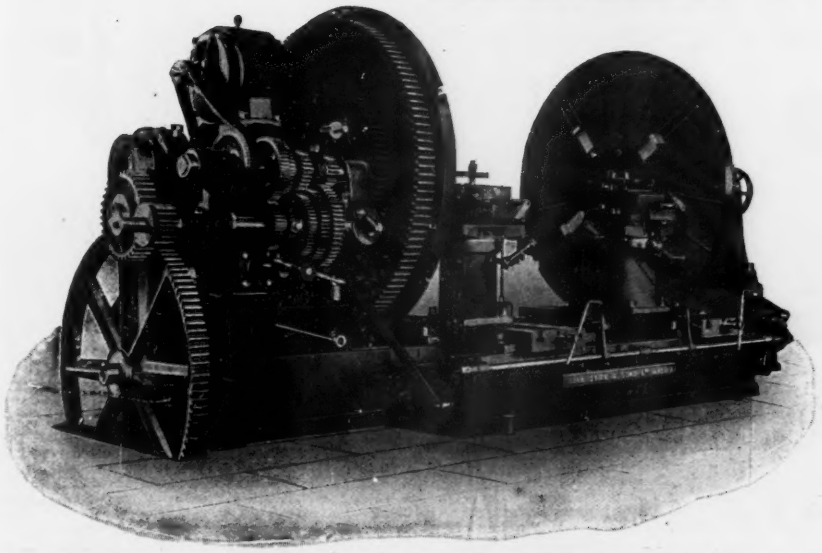

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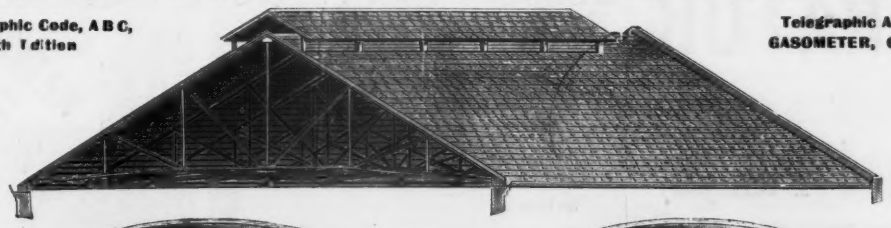

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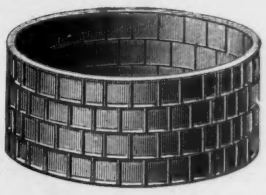

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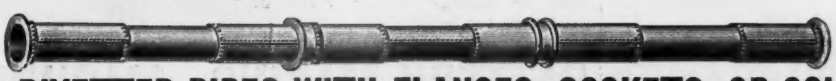

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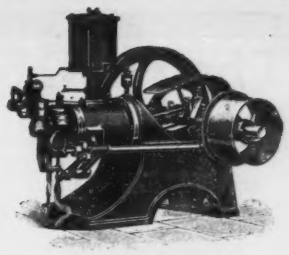

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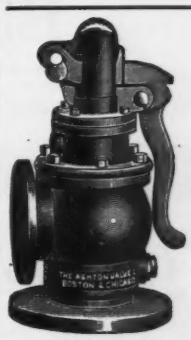

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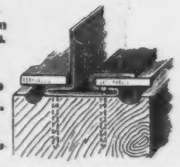

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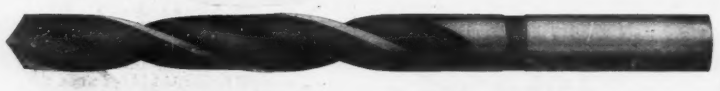

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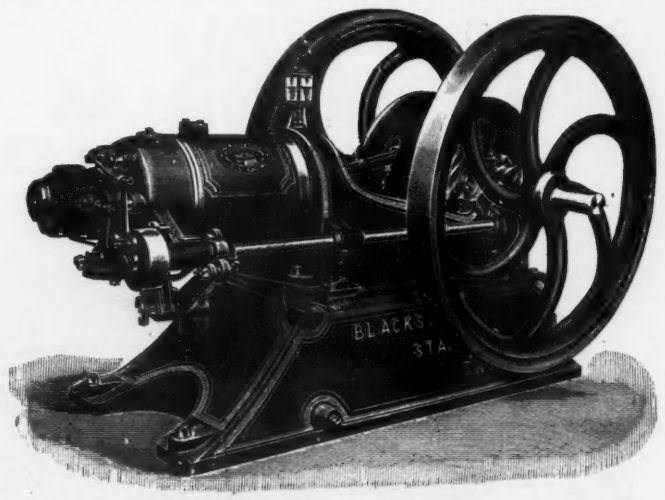

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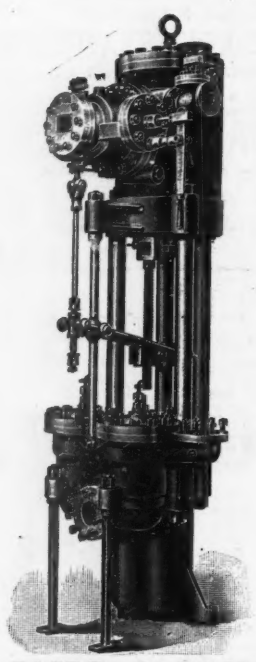

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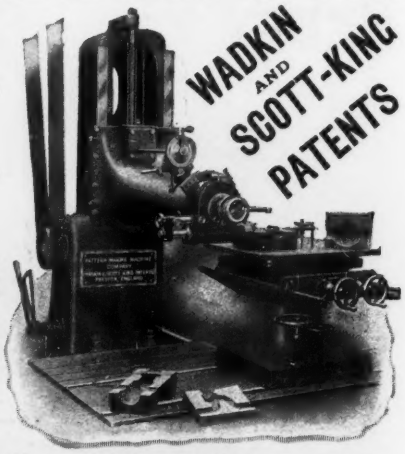

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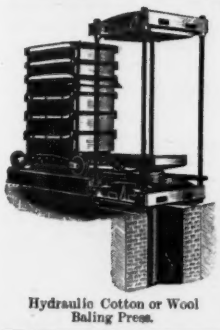

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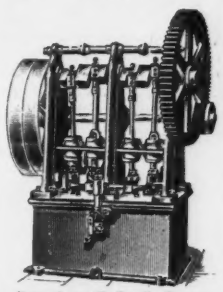

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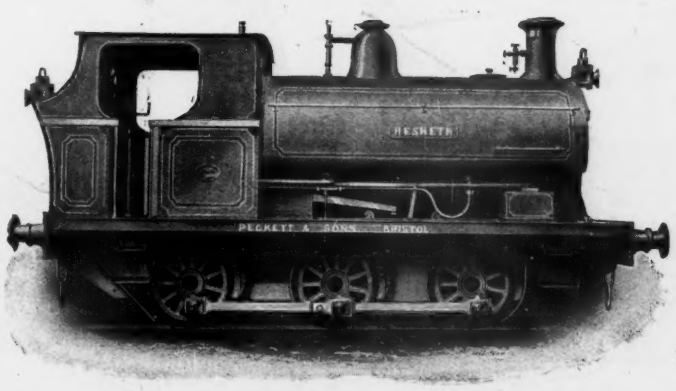

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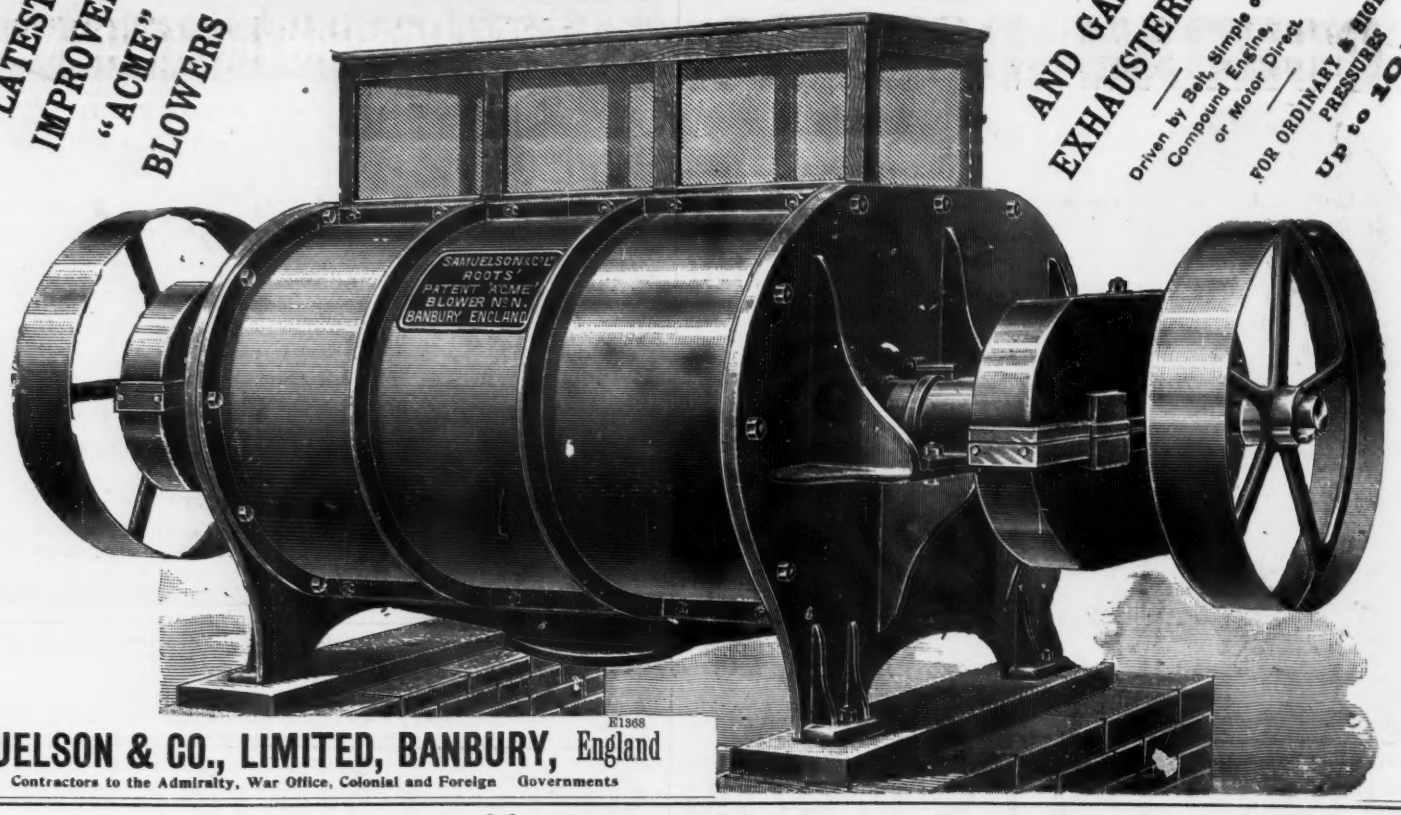

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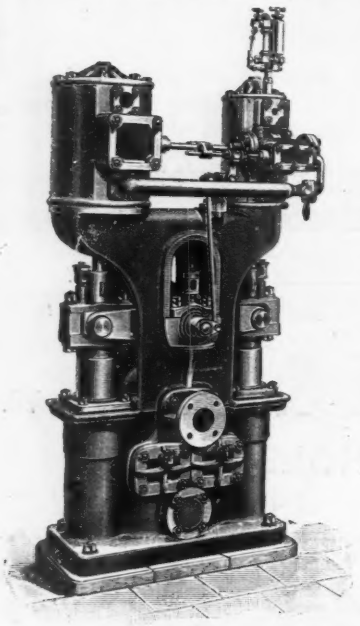

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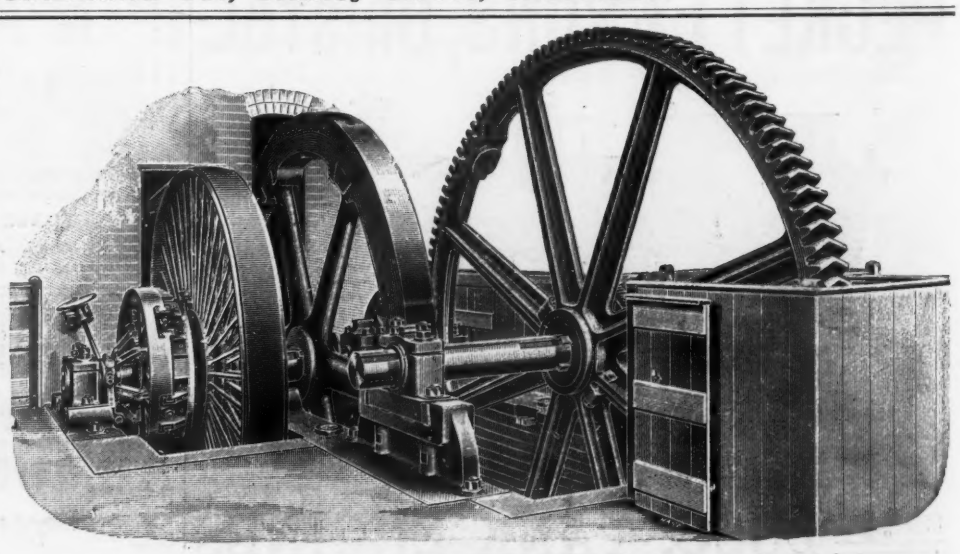

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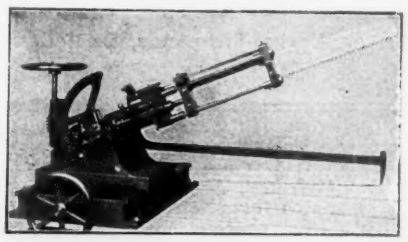

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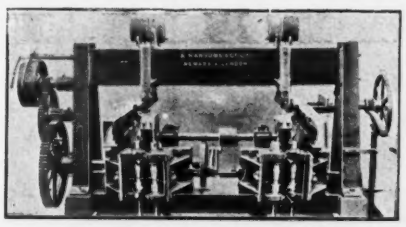

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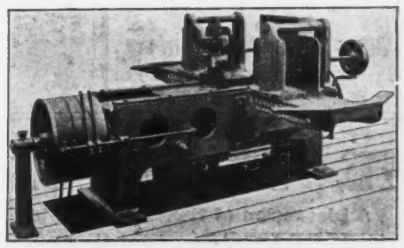

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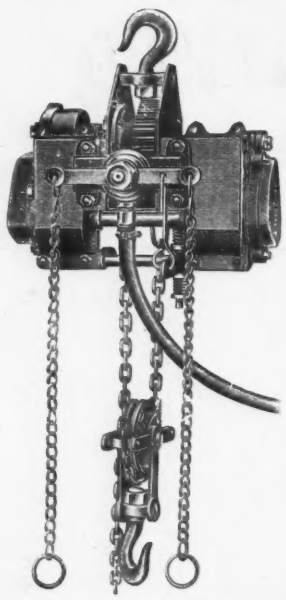

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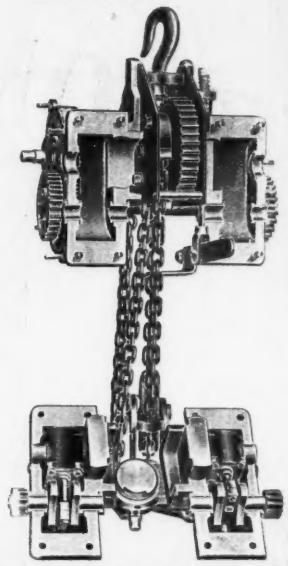

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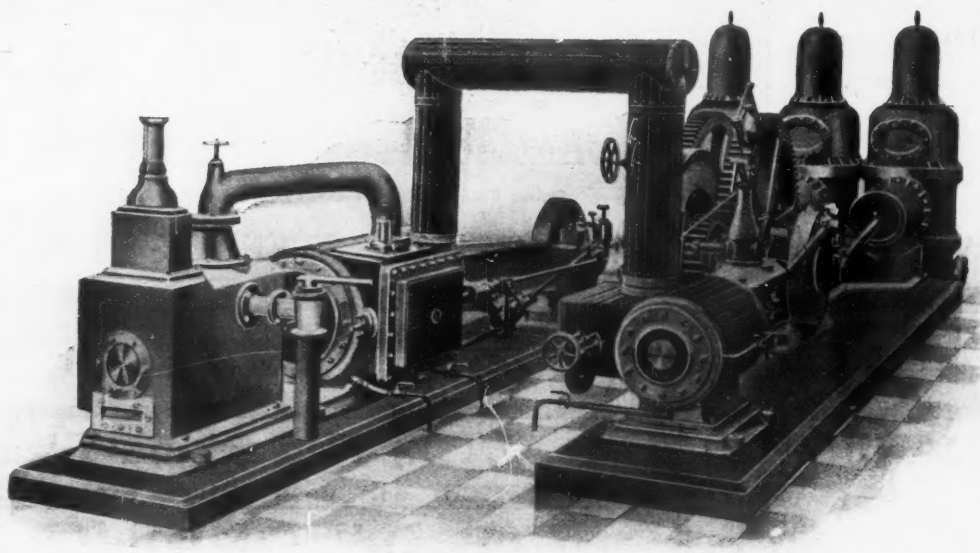

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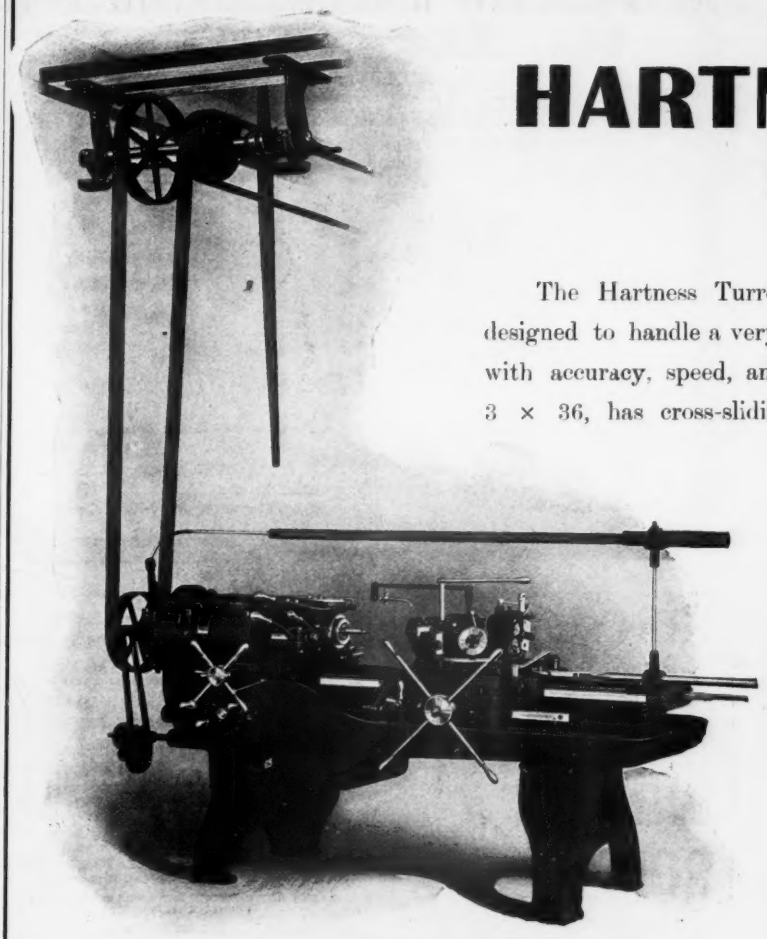

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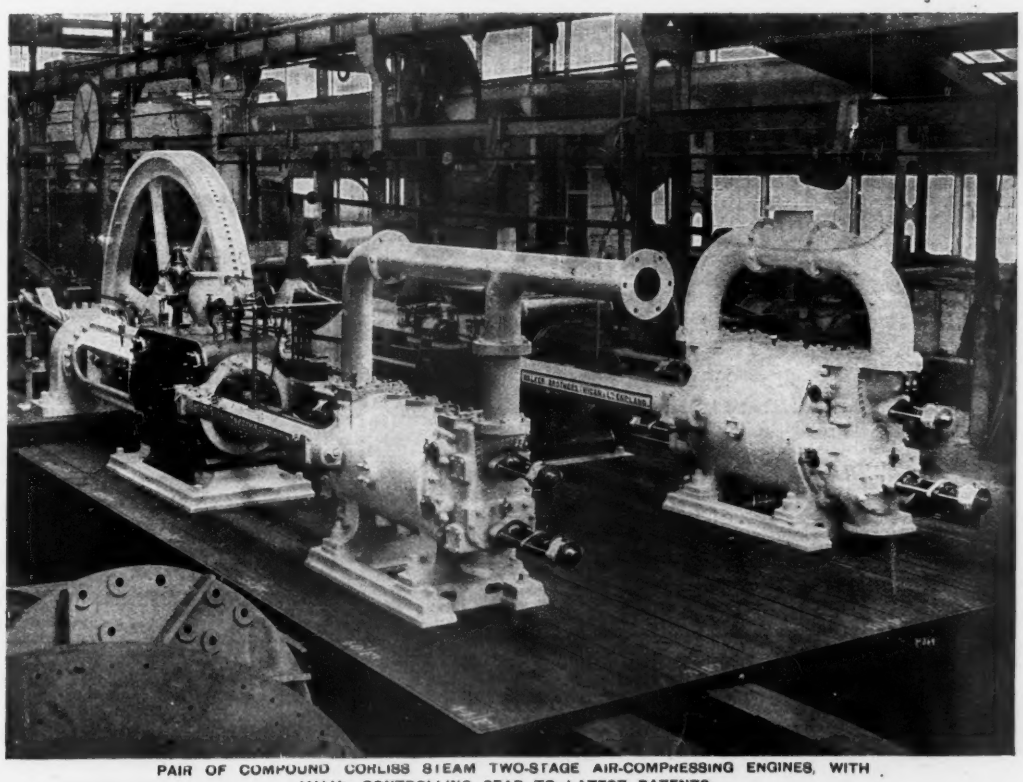

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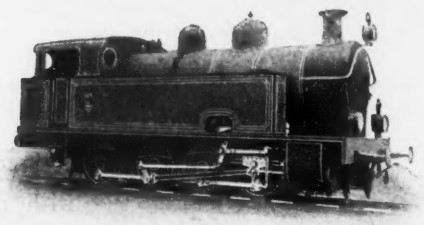

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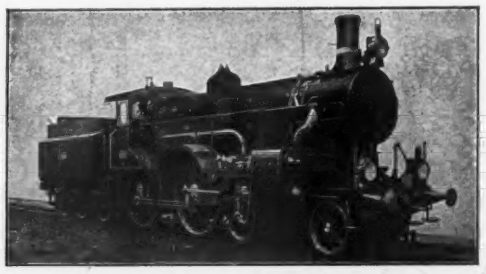

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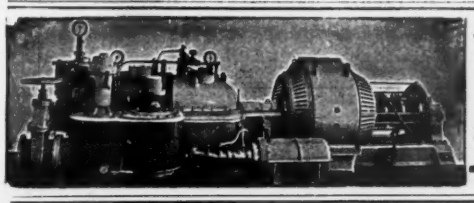

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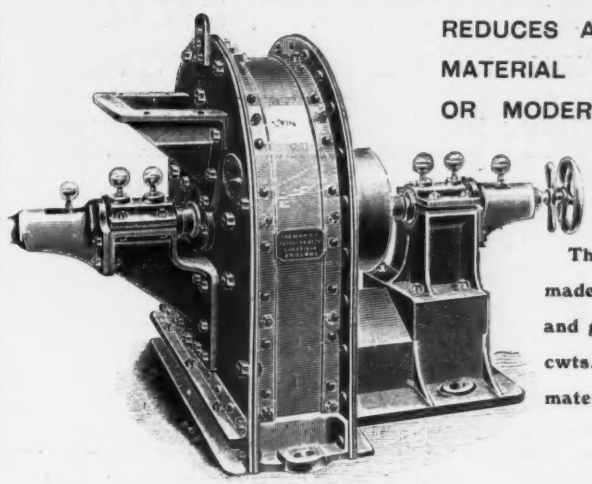

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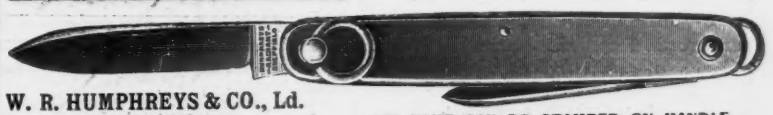

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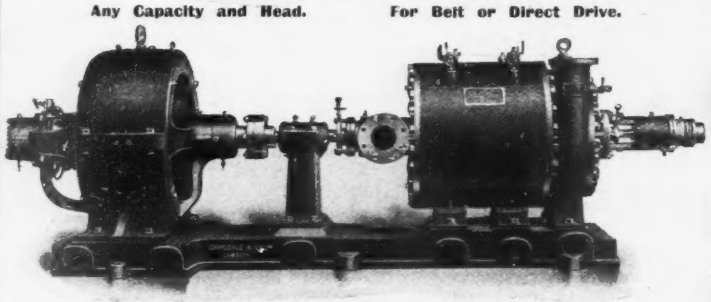

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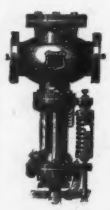

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Chambers, Scott and Co

Collars, Split Grip:
Trier Brothers

Condensers:
Allen, W. H., Son and Co., Ld
Bailey, W. H., and Co., Ld
Caird and Rayner
Cole, Marchent & Morley, Ld
Contraflo Condenser Co., Ld
Edwards Air Pump Syndicate, Ld
Fraser, D., and Sons
Korting Brothers, Ld
Ledward and Beckett, Ld
Mirrlees Watson Co., Ld
Royles Limited
Storey, I., and Sons, Ld
Wheeler Condenser Co

Conveyor Belts:
Hardy Patent Pick Co., Ld
Reddaway, F., and Co., Ld

Conveyors:
Bennis, E., and Co., Ld
Conveyor and Elevator Co
Ewart's Chain Co
Gilbert Little Co., Ld
Heenan and Froude, Ld
Lidgerwood Mfg. Co
New Conveyor Co., Ld
Newell, E., and Co., Ld
Robson, G., and Co.
Simon, Henry, Ld

Cooling Towers:
Balcke and Co

Couplers, Automatic:
Laycock, W. S., Ld,

Cranes:
Appleby Ld
Booth, Jos., & Bros. (Rodley)
Broadbent, T., and Sons
Browning Engineering Co
Chaplin, A., and Co
Coles, H. J., Ld
Cowans, Sheldon and Co., Ld
Craven Brothers, Ld
Fielding and Platt, Ld
Gibbins, R. C., and Co
Grafton and Co
Grieve, J., and Co
Henderson, J. M., and Co
Higginbottom and Mannock Isles, Ld
Jack, A., and Co
Leeds Eng'g & Hydraulic Co
Marshall, Fleming and Co
Morgan, W., and Co
Musker, C. and A., Ld
Ransomes and Rapier, Ld
Russell, G., and Co
Smith, John (Keighley), Ld
Smith, T., and Sons (Rodley)
Taylor and Hubbard
Watson, D., and Co
Wilson, J. H., and Co., Ld

Crucibles:
Doulton and Co., Ld

Destructors:
Heenan and Froude, Ld
Horsfall Destructor Co., Ld

Diving Apparatus:
Barnett and Foster
Siebe, Gorman and Co., Ld

Drawing Materials
MacDuff and Co

Dredge Plant:
East Ferry Road Eng'g Co
Ferguson Brothers
Fleming and Ferguson, Ld
Lobnitz and Co., Ld
Priestman Bros., Ld
Simons, W., and Co., Ld
Smulders, A. F.

Drop Forgings and Stampings:
Armstrong, Stevens and Son
Brooks, J. B., and Co

Drop Hammers:
Brett's Patent Lifter Co., Ld

Electricity:
Brit. Westinghouse Electric Co
Crompton and Co., Ld
Dick, Kerr and Co., Ld
Electric Ordnance and Accessories Co., Ld
Electromotors Ld
Fowler, J., and Co., Ld
Gimson and Co., Ld
Hall, J. P., and Co.
Hartnell, W., and Co., Ld
Hill, G., and Co
India-rubber, Gutta-percha, & Telegraph Works Co., Ld
Jackson, F. H., and Co., Ld
Laurence, Scott and Co., Ld

Electricity (*cont.*)**:**
Phœnix Dynamo Co., Ld
Rees Roturbo Mfg. Co., Ld
Royce Limited
Scott and Mountain Ld
Tangyes Limited
Veritys Limited

Elevators:
Barry, Henry and Co., Ld
Conveyor and Elevator Co
Simon, Henry, Ld

Emery & Carborundum Wheel Truer:
Brunton and Trier

Emery, Emery Wheels, &c.
Carborundum Co
London Emery Works Co
Luke and Spencer, Ld
Mitchell's Emery Wheel Co
Oakey, J., and Sons
Rowland, B. R., and Co
Sterne, L., and Co., Ld

Engine & Boiler Fittings, &c.
Bell's Asbestos Co., Ld
Hopkinson, J., and Co., Ld
Hulburd Engineering Co
Klinger, R., and Co
Smith, S., & Sons, Notting'm

Evaporators:
Davie and Horne
Liverpool Engineering and Condenser Co., Ld
Mirrlees Watson Co., Ld
Weir, G. and J., Ld

Excavators:
Priestman Bros., Ld
Whitaker Brothers, Ld
Wilson, J. H., and Co., Ld

Expanded Metal:
Expanded Metal Co., Ld

Fans & Turbines:
Allen, W. H., Son & Co., Ld
Barry Henry, and Co., Ld
Buffalo Forge Co.
Bumsted and Chandler, Ld
Davidson and Co., Ld
Drysdale and Co., Ld
Escher, Wyss and Co., Ld
Glikes, G., and Co., Ld
Gunther, W., and Sons
Heenan and Froude, Ld
Keith and Blackman Co., Ld
Musgrave and Co., Ld
Pal, M., and Co
Parsons, C. A., and Co
Thwaites Brothers, Ld
Waddle Patent Fan and Engineering Co

Feed-water Heaters:
Caird and Rayner
Clarke, Chapman and Co., Ld
Holden and Brooke, Ld
Royles Limited
Wheeler Condenser and Engineering Co
Wilkinson, Geo.
Wright, Jos., and Co

Fencing:
Baylis, Jones and Baylis, Ld
Hill and Smith
Rowell, D., and Co

Filters, Waste Oil:
Wells, A. C., and Co

Fireproof Construction:
Expanded Metal Co., Ld

Flexible Couplings:
Boving, J. Orten

Flexible Shafts:
Electric and Ordnance Accessories Co., Ld

Forced Draught:
Bennis, E., and Co., Ld
Howden, J., and Co

Forgings:
Brown, J., and Co., Ld
Central Marine Engine Works
Clarke's Crank and Forge Co
Darlington Forge Co., Ld
Grantham Boiler and Crank Co
Hill and Smith
Ince Forge Co., Ld
Jackson, P. R., and Co., Ld
Mills, Exors. of J.
Phillips, J., and Co
Walker Bros., Ld., Wigan

Friction Clutches
Bagshaw, J., and Sons, Ld
Bridge, D., and Co
Brooke, J. W., and Co., Ld
Edmeston, A., and Sons
Kay, J. C., and Co., Ld
Phillips, J. W. and C. J.
Unbreakable Pulley and Mill Gearing Co., Ld
Wigglesworth, F., and Co., Ld

Fuel Economisers:
Baker Blower Engineering Co
Clay Cross Co
Roberts Brothers

Furnace Bars:
Miller and Co., Ld

Furnaces:
Burdon, J., and Sons
Fraser and Chalmers, Ld
Leeds Forge Co., Ld

Fusible Plugs:
National Boiler and General Insurance Co

Galvanizing Plant:
Butterfield, W. F.
Horsfall Destructor Co., Ld

Gas:
Dowson Economic Gas Co., Ld
Duff Brothers and Co
Power Gas Corporation, Ld

Gas Engines:
British Westinghouse Electric and Manufacturing Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Daniels, T. H. and J., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons, Ld
Grice's Gas Engine Co., Ld
Haslam Fdry & Eng. Co., Ld
Hindley, E. S., and Sons
Hornsby, R., and Sons, Ld
Mather and Platt, Ld
National Gas Engine Co., Ld
Premier Gas Engine Co., Ld
Tangyes Limited
Williams, H. W.

Gauge Glasses:
Butterworth Bros., Ld
Guilbert-Martin
Hopkinson, J., and Co., Ld
Moncrieff, J.
Tomey, J., and Sons, Ld

Gauge Glass Protectors:
Hulburd Engineering Co

Gauges:
Klinger, R., and Co
Negretti and Zambra
Schaffer and Budenberg, Ld

Gear Cutting:
Brown, D., and Sons, Ld

Gearing:
Bodley Brothers and Co
Harpers Limited
Jackson, P. R., and Co., Ld
Pochin, E. A., and Bro
Reid Gear Co.
Renold, Hans, Ld
Unbreakable Pulley Co., Ld
Wigglesworth, F., and Co

Governors:
Pollock, Macnab and Highgate

Grinding Machinery:
Bradley Pulveriser Co
Mars-Werke A. G. Nuernberg-Doos
Newell, E., and Co., Ld
Roberts Bros
Smedley Bros., Ld

Grindstones:
Hall and Co

Hammers:
Davis and Primrose
Dunlop, J.
Massey, B. and S.
Perry, T., and Son, Ld
Pilkington, P., Ld
Player, W. and J.
Pollock, Macnab & Highgate
Samuelson and Co., Ld
Thwaites Brothers, Ld

Handles:
Burley and Son, Ld

Harbour Plant:
Stothert and Pitt, Ld
Wilson, John H., and Co., Ld

Haulage Gear:
Carrick and Wardale

Heating Apparatus
Browning, W. E., and Co., Ld
Buffalo Forge Co
Korting Brothers, Ld
Premier Mfg. & Eng. Co., Ld
Standard Engineering Co., Ld

Hose:
Dunlop Rubber Co., Ld
Merryweather and Sons, Ld
Moseley, D., and Sons, Ld

Hydraulic Machinery:
Adlam, G., and Sons, Ld
Berry, H., and Co., Ld
Carrick and Wardale
East Ferry Road Eng'g Co
Fielding and Platt, Ld
Holt and Willetts
Leeds Engineering and Hydraulic Co
Musgrave Bros.
Muskrr, C. and A., Ld
Rice and Co., Ld
Smith, Hugh, and Co
Vacher, H. P.
Youngs

Hydro-extractors
Broadbent, T., and Sons
Pott, Cassels and Williamson

Igniter, Gas and Oil Engine:
Lodge Bros. and Co

India-rubber, &c.:
India-rubber, Gutta-percha, & Telegraph Works Co., Ld
Moseley, D., and Sons, Ld
Reddaway, F., and Co., Ld

Injectors & Ejectors
Davies and Metcalfe, Ld
Green and Boulding, Ld
Gresham and Craven, Ld
Holden and Brooke, Ld
Klinger, R., and Co
Wilcox, W. H., and Co., Ld

Inspection Cars:
Price, Chas., and Son

Inspecting Engineers:
Barlow, J.
Price, J.

Insulating Materials:
Chrome, Rawhide & Tanned Leather Co

Insurance:
Railway Pass. Assurance Co
Vulcan Boiler Insurance Co

Iron and Steel Works Plant:
Clyde Structural Iron Co., Ld
Davy Bros., Ld
Head, Wrightson and Co
Jones, George, Ld
Stevenson, Preston

Iron and Steel Buildings & Roofs:
Ash, J., and Son
Ashmore, Benson, Pease & Co
Bagshaw, J., and Sons, Ld
Barrett and Co
Barrowfield Ironworks, Ld
Braby, F., and Co
Brownlie and Murray, Ld
Bruce and Still, Ld
Clayton, Son and Co., Ld
Cleveland Bridge & Eng'g Co
Clyde Structural Iron Co. Ld
Grover and Co., Ld
Harrison Smith Buildings Co
Handyside and Co., Ld
Lysaght, J., Ld
Main, A. and J., and Co
Mechan and Sons, Ld
Morton, F., and Co., Ld
Piggott, T., and Co., Ld
Rowell, D., and Co
Walker Brothers, Ld

Jointing:
Hudson, J., and Co., Succes's
Knowles and Wollaston
Klinger, R., and Co
Walker, J., and Co

Knives:
Humphreys, W. R., and Co

Laundry Machinery
Summerscales, W., and Sons
Tullis, D. and J., Ld

Lead Machinery:
Krupp Grusonwerk, F.

Lifts and Hoists:
Gimson and Co., Ld
Holt and Willetts
Waygood, R., and Co. Ld
Youngs

Light:
Wells, A. C., and Co

Liquid Fuel:
British Petroleum Co., Ld

Locks:
Kaye, J., and Sons, Ld

Locomobiles:
Reimers, G.
Wolf, R.

Locomotives:
American Locomotive Co
Avonside Engine Co
Bagnall, W. G., Ld
Barclay, Sons and Co., Ld
Beyer, Peacock and Co., Ld
Borsig, A.
Burnham, Williams and Co
Davies and Metcalfe, Ld
Green, T., and Sons, Ld
Hawthorn, Leslie and Co., Ld
Henschel and Sohn
Hudswell, Clarke and Co
Hunslet Engine Co., Ld
Kerr, Stuart and Co., Ld
Lima Loco. and Machine Co
Montreal Locomotive Works
North British Loco, Co., Ld
Peckett and Sons
Stephenson, R., and Co., Ld
Vulcan Locomotive Works

Lubricators:
Hulburd Engineering Co
Trier Bros.
Wakefield, C. C., and Co

Machine Tools (*see* Tools)

Manganese Steel Castings & Forg'gs
Allen, E., and Co., Ld
Cammell, Laird and Co., Ld
Hadfield's Steel Foundry Co

Manholes:
M'Neil, C.
Rolled Steel Forge Co., Ld

Marine Machinery:
Central Marine Engine Works

Mathematical Instruments:
Negretti and Zambra
Stanley, W. F., and Co., Ld

Merchant Iron:
Dunkerley, C. C., and Co., Ld
Farnley Iron Co., Ld
Henderson and Glass
Hanschel and Sohn
Measures Brothers, Ld
Pearson and Knowles Coal Co
Weardale Steel, &c., Co., Ld

Metals:
Atlas Metal and Alloys Co., Ld
Bull's Metal & Melloid Co., Ld
Delta Metal Co., Ld
Glacier Metal Co
Glyco Metal Co., Ld
Phosphor Bronze Co., Ld
Tandem Smelting Syndicate

Meters:
Glenfield and Kennedy, Ld

Mica:
Wiggins, F., and Sons

Mining Machinery:
Davey, Paxman and Co., Ld
Fraser and Chalmers, Ld
Hardy Patent Pick Co., Ld
Head, Wrightson and Co., Ld
Heenan and Froude, Ld
Krupp Grusonwerk, F.
Ransomes, Sims and Jefferies
Robey and Co., Ld
Sandycroft Foundry Co., Ld
Walker Brothers, Wigan

Motor Cars:
Mann's Patent Wagon Co
Thornycroft, J. I., and Co., Ld

Moulding Machines
Samuelson and Co., Ld

Oil Cans:
Kaye, J., and Sons, Ld

Oil Engines:
Blackstone and Co., Ld
Britannia Engineering Co
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons
Hornsby and Sons, Ld
Mirrlees, Bickerton & Day, Ld
Petter, J. B., and Sons, Ld
Price, C., and Son
Vosper and Co., Ld
Wilson, A.

Oil Extractors:
Baker Oil Separator Co., Ld
Holden and Brooke, Ld
Paterson Engineering Co., Ld
Rowland, B. R., and Co., Ld

Oil-gas Apparatus:
Mansfield and Sons, Ld

Oil Launches:
Vosper and Co., Ld

Oil Mill Machinery
Rose, Downs & Thompson, Ld

Oils & Lubricants:
Price's Patent Candle Co
Trier Brothers
Wakefield, C. C., and Co

Packing, Metallic:
Green and Boulding, Ld
Hobdell, Way and Co., Ld
Hudson, J., & Co., Successors
Hulburd Engineering Co
Klinger, R., and Co
Lancaster and Tonge, Ld
Moseley, D., and Sons, Ld
Redfern, S., and Co
United Asbestos Co., Ld
U.K. Metallic Packing Synd
U.S. Metallic Packing Co., Ld
Walker, J., and Co

Paint:
Aldridge, W. V., and Son

Paint Mixers:
Torrance and Sons

Painting Machines:
Wells, A. C. and Co

Patent Agents:
Alexander, E. P., and Son
Harris and Mills
Jensen and Son
Kings Patent Agency
Redfern, G. F., and Co
Roots, J. D.
Vaughan and Son
Watkins Son and Graves

Pattern Makers:
Brown, D., and Sons, Ld

Pattern Making Machinery:
Pattern Making Machine Co
Wadkin and Co

Pencils:
Faber, A. W.

Photo Printing:
Halden, J., and Co., Ld
Hall, R. J., and Co., Ld

Pig Iron:
Brown, J., and Co., Ld
Clay Cross Co
Lilleshall Co

Piles:
British Steel Piling Co

Pipes, Iron & Steel:
Mechan and Sons
Piggott, T., and Co., Ld
Stewarts and Lloyds, Ld

Pile Drivers:
Nasmyth, Wilson and Co., Ld

Pistons:
Lockwood and Carlisle, Ld
M'Neil, C., jun.
Standard Piston Ring Co., Ld

Plates, Steel:
Colville, D., and Sons, Ld
Glasgow Iron and Steel Co., Ld

Plummer Blocks:
Jardine, J.

Portland Cement:
Wouldham Cement Co., Ld

Pneumatic Tools:
Consolidated Pneumatic Tool Co., Ld
Globe Pneumatic Engineering Co., Ld
Howard Pneumatic Eng'g Co

Presses:
Brett's Patent Lifter Co., Ld
Davy Bros., Ld
Fawcett, Preston and Co., Ld
Handa, J., and Sons, Ld
Mills, E., and Son
Rhodes, J., and Sons, Ld
Taylor and Challen, Ld

Printing:
Reveirs, Geo.

Pulleys:
Bagshaw, J., and Sons
Dougias, Lawson and Co
Garnett, P. and C., Ld
Gimson and Co., Ld
Glover and Hobson, Ld
Harpers Limited
Hudswell, Clarke and Co., Ld
Mork Patent Pulley Block Co
Smith and Grace
Thompson and Southwick Ld
Unbreakable Pulley and Mill Gearing Co., Ld

Pulverizers:
Patent Lightning Crusher Co

Pumps:
Air Lift Pump Co
Bailey, W. H., and Co., Ld
Batchelor, R. D.
Bertrams, Ld
Brackett, F. W., and Co
Cameron, J., Ld
Carruthers, J. H., and Co
Clarke, Chapman and Co., Ld
Cochrane, John
Drum Engineering Co
Drysdale, J., and Co
Entwisle and Gass, Ld
Evans, J., and Sons
Fleming and Ferguson, Ld
Glenfield and Kennedy, Ld
Gwynnes, Ld
Hall, J. P., & Sons, Peterboro'
Hathorn, Davey and Co., Ld
Hayward-Tyler and Co
Hughes and Lancaster
Mumford, A. G., Ld
Nasmyth, Wilson and Co., Ld
Owens, S., and Co.
Pearn, F., and Co., Ld
Pulsometer Engineering Co., Ld
Reader, E., and Sons, Ld
Rees Roturbo Mfg. Co., Ld
Richards, R., and Co
Simpson, J., and Co.
Tangyes Limited
Thwaites Bros., Ld
Warner, R., and Co., Ld
Weir, G. and J., Ld
Westinghouse Brake Co., Ld
Wilcox, W. H., and Co., Ld
Worthington Pump Co., Ld

Railway Plant:
Askham Bros. and Wilson, Ld
Bagnall, W. G., Ld
Baker, J., and Co. (Rotherham)
Barclay, Sons and Co., Ld
Birch, J., and Co., Ld
Bolling and Lowe
Cammell Laird and Co., Ld
Continuous Rail Joint Co
Cravens, Limited
Dick, Kerr and Co., Ld
Findlay, A., and Co
Fowler, J., and Co., Ld
Glasgow Rail and Engin'g Co
Griffith, W., and Sons
Harrison and Camm, Ld
Hillen Steel Rail Works
Hudson, R.
Isca Foundry Co
Kerr, Stuart and Co., Ld
Koppel, A.
Laycock, W. S., Ld
Leeds Forge Co., Ld
Lion Spring Co
Maclellan, P. and W., Ld
McLachlan and Co
Midland Railway Carriage Co
Patent Shaft and Axletree Co
Pickering, R. Y., and Co., Ld
Ransomes and Rapier, Ld
Renshaw, W. R., and Co., Ld
Stableford and Co
Summerson, T., and Sons, Ld
Turner, G. R., Ld
United Electric Car Co., Ld

Rams, Hydraulic:
Bailey, W. H., and Co., Ld
Vacher, H. P.

Reducing Valves:
Auld, D., and Son
British Steam Specialities
Royles Limited

Refrigerating Machinery:
Hall, J. and E., Ld
Hasham Foundry and Engineering Co., Ld
Linde British Refrigeration Co
Pulsometer Engineering Co
Sterne L., and Co., Ld

Rivet Binders:
Sloan Electrical Co., Ld

Rivets:
Bifurcated & Tubular Rivet Co

Rock Drills:
Daw, A. and Z.

Rolls and Rolling Mill Plant:
Perry, T., and Son, Ld
Teanesis, R. B., Ld

Roofs (*see* Iron Bldgs.)

Saw Mill Machinery (*see* Woodworking Machinery)

Screwing Tackle
Chatwin, T.
Hulse and Co., Ld
Widdowson, J. H.
Williamson, J

Sea Water Distillers:
Fawcett, Preston and Co., Ld

Shafting:
Govan Shafting Co
Harpers Limited
Mackies, Ld
Platt, S., Ld
Wigglesworth, F., and Co., Ld

Shearing Machines
Jones, Geo., Ld

Shipbuilders:
McGregor, P., and Sons

Ship Carbons:
Ship Carbons, Ld

Ships' Plumbing Work:
McAlpine and Co., Ld

Signalling, Power:
McKenzie, Holland & Westinghouse Power Signal Co

Small Tools:
Birmingham Small Arms Co
Brayshaw, S. N.
Chatwin, T.
Patent File and Tool Co., Ld
Wrigley, E. G., and Co., Ld

Soda Water Machinery:
Barnett and Foster

Springs:
Lancaster and Tonge, Ld
Tempered Spring Co., Ld

Steam Engines:
Brazil, Straker and Co., Ld
Brearley, Fairbank, Ld
Brit. Westinghouse Electric Co
Brotherhood, P., Ld
Burrell, C., and Sons
Cammell Laird and Co., Ld
Cole, Marchent and Morley, Ld
Davy Bros., Ld
Dodman, A., Ld
Easton and Bessemer, Ld
Galloways Limited
Hindley, E. S., and Sons
Howden, J., and Co
Lees, T. and R.
Plenty and Son, Ld
Reader, E., and Sons, Ld
Reavell and Co., Ld
Robey and Co., Ld
Rodger, A., and Co
Ross and Duncan
Ruston, Proctor and Co., Ld
Wilson, A.

Steam Launches:
Cochran and Co., Annan, Ld
Fleming and Ferguson Ld
Hayes, Ed.
Lobnitz and Co., Ld
Simons, W., and Co., Ld
Simpson, Strickland and Co
Yarrow and Co., Ld

Steam Separators:
Holden and Brooke, Ld

Steam Traps:
Hobdell, Way and Co., Ld
Lancaster and Tonge, Ld

Steel:
Allen, Edgar, and Co., Ld
Armstrong, Whitworth and Co
Beardmore, W., and Co
Brit. Westinghouse Elec. tric Co
Brown, Bayley's Steel Works
Colville, D., and Sons, Ld
Firth, T., and Sons, Ld
Glasgow Iron and Steel Co., Ld
Hadfield's Steel Foundry Co
Howell and Co., Ld
Jessop, W., and Sons Ld
Rogerson, J., and Co
Spencer, J., and Sons
Steel Company of Scotland
Stewarts and Lloyds, Ld
Turton, T., and Son
Vickers, Sons and Maxim, Ld

Steel Sheets:
Lysaght, J., Ld

Steel Structural Work (*see* Iron and Steel Buildings)**:**

Stills and Distilling Plant:
Blair, Campbell and McLean
Mirrlees Watson Co., Ld
Pontifex and Wood

Stokers, Mechanical, &c.:
Bennis, E., and Co., Ld
Neil, J.
Proctor, Jas.
Triumph Stoker, Ld
Underfeed Stoker Co., Ld

Stone Breakers:
Baxter, W. H., Ld
Goodwin, Barsby and Co
Marsden, H. R.
Mason Bros.

Suction Gas Plant (*see* Gas Engines)

Sugar Machinery:
Blair, Campbell & McLean, Ld
Blake, Barclay and Co
Craig, A. F., and Co., Ld
Manlove, Alliott and Co., Ld

Superheaters:
Cruse Superheater Co
Galloways Limited
Schmidt Superheater Co., Ld
Superheater Units Co
Tinker, Shenton and Co., Ld

Surveying Instruments:
Clarkson's
Stanley, W. F. and Co. Ld

Tanks:
Ash, J., and Son
Braby, F., and Co., Ld
Butterfield, W. F.
Clayton, Son and Co., Ld
Newton, Chambers & Co., Ld

Telemotors:
Mactaggart, Scott & Co., Ld

Time Checkers:
Llewellin's Machine Co

Tools:
Archdale, J., and Co
Asquith, W., Ld
Binns Bros.
Birch, G., and Co
Buck and Hickman, Ld
Buckton, J., and Co., Ld
Butler, J., and Co
Cameron, J., Ld
Campbells and Hunter, Ld
Carron Company
Centaur Motor and Eng'g Co
Chambers, Scott and Co
Circulators and Co
Clifton and Baird
Clifton and Waddell
Craven Bros., Ld
Crosier, Stephens and Co
Daniell, S. A., Ld

Tools (*continued*)**:**
Davis and Primrose
Dean, Smith and Grace, Ld
De Bergue and Co. Ld
Dempster, Moore and Co. Ld
Drummond Bros., Ld
Eclipse Tool Co., Ld
Grice, W., and Sons, Ld
Heap, J., and Co., Ld
Herbert, A., Ld
Hetherington, J., & Sons, Ld
Hill, Isaac, and Son
Hulse and Co., Ld
Jones and Lamson Machine Co
Kearns, H. W., and Co., Ld
Kendall and Gent, Ld
Lang, J., and Sons
Loewe, L., and Co., Ld
McKendrick, W. D., and Co
Muir, W., and Co
Noble and Lund, Ld
Pfeil and Co
Platt, S., Ld
Pratt, F., and Co., Ld
Redman, C., and Sons
Reinecker, J. E.
Richards, G., and Co
Rider, T., and Son
Schuchardt and Schutte
Seller, Sonnenthal and Co
Shanks, T., and Co
Smith and Coventry, Ld
Smith, Hugh, and Co., Ld
Stirk, J., and Sons
Storey, J. H., & Co
Tangyes Limited
U.S. Metallic Packing Co., Ld
Wade, H. W., and Co
Ward, T. W., Ld
Webster and Bennett
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